INSECTICIDES, FUNGICIDES AND WEEDKILLERS

E. BOURCART, D.Sc.

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A PRACTICAL MANUAL ON THE DISEASES OF PLANTS AND THEIR REMEDIES, FOR THE USE OF MANUFACTURING CHEMISTS, AGRICULTURISTS, ARBORICULTURISTS AND HORTICULTURISTS

BY

E. BOURCART, D.Sc.

TRANSLATED FROM THE FRENCH, REVISED AND ADAPTED TO BRITISH STANDARDS AND PRACTICE

BY

DONALD GRANT

WITH EIGHTY-THREE TABLES AND TWELVE ILLUSTRATIONS

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AUTHOR'S PREFACE.

EVERY year the diseases of plants become more numerous, their economic importance increases, and the number of those interested becomes greater; more numerous by the means of communication established between different countries, and by more frequent commercial intercourse; more important and more dangerous because they prevent the heavy yields of different crops which should be obtained from the high farming with which the prosperity of our farmers is so closely associated; the number of those interested increases because gardening for pleasure, ornamental horticulture, extends daily more and more amongst all classes of society. It therefore becomes indispensable that the farmer, the gardener, and the amateur flower grower should possess a treatise in which they can easily find the cause of the diseases which dishearten them, and at the same time an efficient remedy capable of circumscribing them and of preventing their return.

So as to render this treatise complete in itself it was deemed necessary to pass in review the numerous experiments made up to now to suppress and prevent plant diseases.

The author has striven from the aggregate of the results reported to frame certain scientific rules which appear to determine the success of certain classical methods and to explain certain notorious failures, rules which may serve as a useful guide to future experiment and aid in the discovery of new products of greater efficiency than those now at our disposal.

The preventive and combative treatment of the diseases of plants requires a profound knowledge of the parasite as well as the product used as a remedy. Success depends on the judicious choice of the remedy utilized and the manner in which it is applied.

The plan of this book is therefore conceived in such a way

as to enable the less initiated to find with the greatest ease the information which they require when they desire to treat a diseased plant.

The author has annexed to the book a glossary of the principal diseases of plants and the parasites which occasion them. The descriptions given therein afford the requisite information as to the different states of evolution of the parasites whilst they are vulnerable, because such knowledge is indispensable to form a decision as regards the periods at which it may be desirable to apply the effective remedies preventively and curatively.

In the index, after the name of the cultivated plant, there follows a list of the diseases from which it may suffer. It suffices to turn to the glossary when the reader does not know the cause of any disease, and the name of the disease being identified to find in the index the page where its treatment is described.

The author's object will be attained if this book serves as a guide to those who have sought most often in vain a means of restoring health to plants which form the object of their care or the joy of their leisure.

E. BOURCART.

PARIS, 1911.

TRANSLATOR'S PREFACE.

DR. BOURCART has done his work so well that the translator would fail in his duty if he did not insist on one point on which the author is silent, *viz.*, the enormous value of the great number of tried recipes—recipes which have passed the ordeal of a capable and wise censorship—embodied in this treatise to every one interested, whether farmer, gardener, forester or last but possibly not least the manufacturing chemist. But the reader will soon discover for himself that this is not the only feature which renders the book unique of its kind.

DONALD GRANT.

LONDON, *November*, 1912.

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INTRODUCTION.

Relative and Absolute Diseases.—Plants, like man and animals, in virtue of their living cellular constitution, are liable to disturbances of their physiological equilibrium, that is, to diseases. The diseases of plants are quite as well defined as those of animals, and a certain analogy exists between them, so also with the inducing causes. We again find amongst these causes the same physical, chemical, or parasitic elements. These causes generally co-operate to produce disease; but one cause is always preponderant and serves as a basis for classification. Plant diseases are divided into (*a*) *relative* and (*b*) *absolute* diseases. Relative diseases are a return to the natural wild state of the plants artificially selected and profoundly modified by man, and so it is that Brussels sprouts, turnip cabbage, and the different species of cauliflower are derived from a species of cabbage to which a disease *Parenchymatosis* has been imparted artificially by over-nitrogenous feeding systematically pursued for several generations. The tendency of these plants to form large fleshy buttons, in the form of a cabbage-head, or excrescence of the stem, is not at all inherent in the species, and it is not unusual in dry seasons to observe a return of these plants to the primitive condition. This degeneration is regarded as a *relative disease*. It is the same with fruit trees; we skilfully maintain by pruning the morbid condition which forces them to produce an exaggerated amount of fruit so as to accomplish in this way the end which we assigned to them. Their return to the natural state is regarded as a degeneration or a *relative disease*. *Absolute* diseases result, on the other hand, from more or less profound alteration, general or local, of the organs of the plant; from a more or less extensive and complete alteration of the cellular tissue. It is to *absolute* diseases alone that the etiological observations which are about to be examined apply.

Etiology.—Etiology is that part of pathology which is concerned with the research of the origin of diseases, and examines the causes which induce them. The latter are divided into *effective* causes (those which actually cause the disease) and *adjuvant* (helping, predisposing) causes (those which place the plant organism in such a condition that the effective causes can act). In practice, these causes are confused and linked together in such a way that an adjuvant cause in a given disease may become an effective cause in another disease. It has been seen that the etiological factors of disease may be divided into (1) physical, (2) chemical, and (3) parasitic.

(1) Physical Causes.—These depend on climate and season. Heat, cold, drought, and humidity, more or less sun-light, are factors

which greatly influence plant growth. They cause deadly plant diseases when all favourable conditions do not work together. Here, as in the animal kingdom, the great law of selection intervenes. Only plants able to live in the existing climatic conditions will subsist, the others suffer, fall ill, and disappear. There are few remedies for climatic causes.

(2) **Chemical Causes.**—These relate, especially, to the chemical composition of the soil, from which the plant draws the elements required for life and growth. These may exist too abundantly, or not in sufficient amount. Ré terms those diseases due to an excessive amount of nutritive elements *sthenic* diseases, and those due to an insufficient amount *asthenic* diseases. These physical and chemical causes favour the hatching of parasitic diseases. Plants weakened by these causes can exert little or no cellular resistance to being overrun by parasites, which find in them a medium favourable to their growth and development, for however unfavourable these conditions may be to the development of the plant, they are, precisely, those which favour the evolution and multiplication of parasites.

(3) **Parasitic Causes.**—The evolution of all parasites, animal or vegetable, should be well known, as they are neither injurious nor destructive to the same extent in different phases of that evolution. Each parasite has a very characteristic evolution, more or less long, always the same for the same species. (1) *Animal Parasites.*—These belong to the most diverse classes, but insects especially occasion the most frequent and perceptible damage. The insect originates in the egg. The insect which it contains passes through very different conditions, until after a greater or less length of time it becomes perfect, that is, capable of laying eggs to ensure its reproduction. The sequence of these intermediate conditions is called metamorphosis, and the different forms, larvæ, caterpillars, grubs, chrysales, etc. It is especially in the larva form that the insect is most injurious, because it sometimes remains several years in that condition. That form represents in every instance the longest period in the life of the insect. A sound knowledge of these metamorphoses, of the periods at which they take place, and the spots where they occur will render the struggle against insects at the moment of their evolution—when they are the most sensitive to insecticides and when they cannot withstand their energetic action—comparatively easy. (2) *Vegetable Parasites.*—These include fungi and certain phanerogams. Fungi have also an evolution, differing greatly with the species, and often very complex. Their method of reproduction, the time and place where the spores are produced as well as the plants on which these spores can germinate, should be known. The elements of reproduction of fungi are spores (name given to seeds of fungi). These spores develop when climatic conditions permitting their evolution are realized. The *mycelium* (this is the name given to the new-born parasite) can then expand, either in the interior or on the exterior of the plant. In both cases it lives at the expense of the cellular tissue, and in so doing produces characteristic diseases. Organs of reproduction are formed on the mycelium, from which spores that spread the disease are de-

tached. The spores produced differ wi h the season and locality of the plant. They are differentiated into (1 summer spores, very delicate, which generally produce a mycelium forthwith, and (2) winter spores, very hardy, which do not develop until after a winter passed as such. No general rule can be given as to the evolution of fungi. It differs as much from one species to another as in that of insects. Species exist of very complex forms, the evolution of which obliges them to pass each cycle on very different species of plants. The suppression of one of these plants in the district may lead to an instantaneous and complete stoppage of the disease. These fungi are not all equally injurious. The following classification, based on their action on plants, has been adopted : (*a*) *Absolute parasites*, (*b*) *Wound or weakness parasites*, and (*c*) *Facultative parasites*. (*a*) The first, the most dangerous, are capable of attacking healthy plants. (*b*) The second can only attack the plant if its physiological condition is abnormal, i.e. attacked by disease, if its *vital* energy be diminished by climatic conditions ; or if hail, or frost, grub, or other cause, has made an opening in the epidermis, enabling them to penetrate into the interior. (*c*) The third are the fungi formerly termed saprophytic fungi as opposed to parasitic fungi. Whilst the latter draw their nutriment from the living cell, the former live on inanimate organic matter. It has been ascertained, nevertheless, from the profound study of cryptogamic diseases that saprophytic fungi may, in most instances, become dangerous parasites if, through special circumstances, the plant cell may happen to contain elements sought after by one of these fungi. Thus the *penicillium glaucum*, the well-known green mould, which usually grows on an inanimate medium, is attracted during the ripening of fruit by the sugar contained in the latter, and penetrating therein causes them to rot. (3) *Microbe Parasites.*—In the case of a microbe parasite it is especially necessary to know what factors induce its development, which is closely connected with the composition of the cellular substance, the temperature, and the moisture. Plants, however, suffer less from these than animals, because the reactions of vegetable plasma are acid, which are less favourable to their evolution than an alkaline medium. However, the daily discovery of parasitic microbes helps to throw light on some of the morbid phenomena of plants, and microbes appear to play a most important rôle in plant pathology.

The antagonism between animate beings, as much animal as vegetable, which live in the same medium does not give rise solely to very weak, morbid conditions, but also to relations between beings of very different species, which are advantageous to the two antagonists. These associations are termed *symbioses*. De Bary, generalizing the term *symbiosis*, distinguished (1) *Mutualistic symbiosis* or advantageous co-operation of the two associates, and (2) *Antagonistic symbiosis*, where the one lives at the expense of the other. Vuillemin, on the other hand, calls the first association symbiosis and the second antibiosis.

1. **Mutualistic Symbiosis.**—Many cases of evident symbiosis occur between phanerogams and cryptogams, between cryptogams and microbes, and between phanerogams and microbes. Amongst these sym-

biotic associations the lichens must be regarded as the most typical and the most perfect example. It is the most complete association known, where the elements, fungus, and alga are so closely associated that henceforth it is impossible for them to live apart. The most interesting cases are those of evident symbiosis between certain fungi and trees such as *Fagus* (beech), *Corylus* (hazel), *Castanea* (chestnut), and several species of *Coniferæ*. In this symbiosis, known as *Mycorhiza*, the *mycelium* of the fungus invades the roots of the tree, and, whilst borrowing the necessary elements of life from the tissues of the plant, cedes to it the nutritive elements favourable to its growth. Other symbioses of great importance to agriculture exist between certain cultivated plants and certain microbes. We have, on the one hand, the *Bacteriorhiza* of Hiltner and Strömer, in which bacteria, whilst drawing their nutriment from the cells of the root epidermis of *Beta* (beet) and *Pisum* (pea), without injuring the latter prevent injurious fungi, such as *Phoma* and others, from invading and destroying these plants. Again, microbes and *Leguminosæ* are associated together: *Rhizobium leguminosarum* (Frank) and *Bacillus radicola* (Beijerinck). These bacteria live on the excrescences, the characteristic nodosities which they produce on the roots of the *Leguminosæ*. If they draw the necessary elements of life from the cellular tissue of the root, they as a matter of compensation cede to the nursing plant nitrogen of the air in an assimilable form. These symbioses are favourable to the development of the plant, and the rupture of this association necessarily creates a less prosperous state, more akin to a grave pathological condition; the more complete the symbiosis the more the health of the plant depends on the nutritive elements with which these associates are capable of supplying it. In the disinfection of the soil by chemical agents it sometimes happens that by destroying noxious parasites, the mutualistic parasites are destroyed at the same time, and that in curing one disease another is created. Pure cultures of these useful bacteria, or of the mycelium of mutualistic fungi, must, therefore, be spread on the fields some time after disinfection. Pure cultures of these bacteria are on the market, under the name of "Nitragine," etc. The very contradictory results obtained on the large scale by the use of pure bacteria arise from the fact that these should be applied, not upon *any* soil, but on *a* soil disinfected by carbon disulphide. The soil is like a wort, and there is a great analogy between selected leavens (yeasts) and soil bacteria. The selected leavens cannot yield a result except on wort previously freed —by sterilization, by means of heat—from any other leaven which would hinder their development. In the same way, the soil which it is desired to sow with mutualistic bacteria should be freed, by previous disinfection, from the elements which can, by their presence, oppose the normal evolution of these useful bacteria. Each plant possesses its own bacteria, and in each particular case requires the aid of a pure, selected, and well-defined culture of microbes.

2. **Antagonistic Symbiosis.**—The most common result of the antagonism between animated beings is the parasitic disease—general or local—to which the plant, badly equipped, or in bad condition to resist

the attack of its enemies, succumbs. The number of plant parasites is immense, and they are found in all classes of animated beings (phanerogams, cryptogams, bacteria) as well as animals (worms, insects, acari) living at the expense of the plant. They all become more dangerous, the one more than the other, in so far as they find the medium favourable to their development and extraordinary multiplication—a medium of constant and invariable composition, and climatic conditions lying between narrow limits, to which are intimately linked the growth and reproduction of each organism. Between enemies the struggle is constant. The reaction of the plant against the parasites which threaten it, its cellular activity, which opposes to them its layers of bark which creates deposits of tannin, of acids in the cells, layers of wax on the epidermis, prevent it from succumbing. There is no disease until the reactive forces of the plant become powerless to prevent the development of parasites, until the disposition of the subject, and special and exceptional conditions, facilitate their evolution, increasing their virulence and their number. There is, however, disease when the parasitic antagonists imported from a foreign country (as was the case with certain insects imported from America, and as is seen in America as regards insects of European origin) are deprived of their natural parasites capable of hindering their abnormal multiplication. Great invasions of parasites must be regarded, in fact, as accidents, for nature has attached to each ravager one or more parasites which live at its expense, just as it itself lives at the expense of the plant. These parasites obey the same laws as the ravagers, multiply with the same rapidity as the latter, and by diminishing their number is the check which nature opposes to the abnormal multiplication of the species. Moreover, sudden changes of temperature at the time of the casting of the skin of the larvæ of the insects—then very delicate—frosts, heavy rain, free electricity, appear to be some of the causes which hinder the development of too great a number of parasites. In nature these causes prevent epidemics, which would be very rare if man did not, by his methods of culture, create specially favourable conditions for the evolution and multiplication of parasites. Formerly, this state of affairs was remedied by the bare fallow ; to-day, rotations are preferred ; to-morrow, the annual disinfection of the soil by means of carbon disulphide, that of the underground and aerial (above ground) part of plants by insecticides and anticryptogams will definitely abolish a condition which necessarily results from our methods of cropping. We must replace by new processes the action of stable equilibrium which is manifested in nature and which we have suppressed. It will be seen, however, that the complete destruction of parasites is not indispensable, but even injurious, and that disinfection should only re-establish equilibrium, a *modus vivendi* between the plant and its parasites. It is necessary, in fact, to avoid diminishing in the plant the reactive force of the cells, so that these may always be armed and active, and able at any moment to sustain the struggle against parasites. This equilibrating disinfection is only realized, up to now, in the treatment of the vine against *Phylloxera* and cryptogamic parasites by the annual treatment (*a*) of the soil by weak applications of carbon disulphide, of dissolved sulpho-

carbonate, and (*b*) the aerial or above-ground parts of plants by sulphuring, multiple spraying with weak cupric bouillies, washing of the stock with ferrous sulphate (green vitriol), and by scalding or hot water treatment. The number of plant diseases daily increases, as now we do not solely cultivate native plants, but more and more foreign species imported into the country. The deportation of the latter places them in new conditions against which nature has not armed them ; and in the country of their exile they are defenceless against parasites. But these plants import parasites which find a favourable medium for their evolution in the plants of our country, against which the latter are not armed. Thus it is that very severe diseases have appeared in our crops, and that America has been dowered with parasites, harmless with us, but formidable enemies in that new country.

Therapeutics.—Therapeutics is that part of medicine which treats of curative agents and studies the manner of using them in the treatment of disease. *Vegetable therapeutics* is based on physiological data on the knowledge of the physico-chemical properties of curative agents, on their action (1) on the plants to be treated, (2) on the factors which cause the disease. It will therefore be necessary to indicate in the case of each chemical product used in the treatment of plant diseases (1) The process of manufacture of the chemical product. (2) Its physico-chemical properties, a knowledge of which facilitates the preparation of therapeutic specialities and makes known their mode of action. (3) Its use in human medicine. (4) Its action on the plants treated. (5) Its action on the parasites to be overcome, or on the factors injurious to plants. Curative treatment is *surgical* when the effective causes are suppressed without the aid of chemical products, and *chemical* when recourse is had to the aid of chemical products. The use of the one does not exclude the use of the other, and the two utilized simultaneously may produce a better effect.

Surgical Treatment.—Surgery, or operatory medicine, is the part of medicine which comprises the intervention of the *naked* hand or the hand *armed with instruments.* The intervention of the hand armed with instruments has given rise to vegetable surgery, the intervention of the naked hand to the *methods of destruction of parasites*—picking, collecting, trapping, baiting.

Vegetable Surgery.—Vegetable surgery has many analogies with animal surgery. An organ deeply attacked or capable of being regarded as a seat of infection should be removed in either case. That is so much the more easy in the case of a plant, as the latter is a being whose growth, by budding, is indefinite, and that the organs removed are replaced by equivalent organs in a comparatively short time. The researches of Reaumur, Ratzeburg, Robert, Count Jaubert, and Knight have shown how vitality may be restored to a sickly tree. The best known process, called "phloioplasty," consists in removing in a partial or general way the old bark from the trunk and large branches of a diseased tree as far as the liber. The dressing of the wounds, which ought to be kept as clean as those of man, is done thus : If the disease be so deep seated as to necessitate exposing the

wood, a protective coating, after cleaning, is spread on the surface of the wood, which preserves the wound from contact with the air, but if there be a living piece of bark (parenchyma, cortical fibres, or liber), whether in the heart of the wood or on its edges, it must be respected and protected by some folds of the suberose layer. In this latter case, the application of a coat of tar would be fatal, especially if used hot. The artificial wound method is practised to restore health to a tree whose bark is invaded by *scolytus*. Longitudinal incisions are made on the parts attacked, penetrating the cortical layers only as far as the liber. In serious cases, a narrow band is removed from the suberose layers. This superficial incision induces a flow of sap, leads to the formation of new tissue, and stops the transversal progress of the larvæ of the *scolytus*. If the tree has been invaded in all parts by scolytes, the great part or even the whole of the circumference of the tree is decorticated but so as not to wound living tissue. When the strips are removed, hems are formed; when the tree is completely decorticated, a network of cortical fibres is seen to form on the surface, the diameter of the tree grows, and a new bark is formed. Surgical interventions of this kind, although rarely employed, may be useful when chemical treatment has no effect.

Methods of Destroying Parasites by the Naked Hand.—When a parasite is of appreciable size, and especially when it forms visible and accessible colonies, its suppression by catching gives immediate results. On a large scale the parasites may be induced to localize themselves in spots where their destruction is easy. According to circumstances the methods used are (1) Picking or catching, (2) Traps or baits.

Picking and Catching.—Coleopterous insects (cockchafers), grubs of butterflies, especially when they live in colonies, the agglomeration of eggs of certain Bombyx (Ocneria) are picked. This picking is generally done by hand. However, when it is desired to pick small insects rapidly, tinned iron funnels with a wide mouth are used, above which the infected organs of the plants are shaken. The neck of the funnel is connected with a cloth sack into which the parasites fall (altise of vine). The gathering of insects on farm land is also accomplished by aid of poultry. For this purpose there are portable hen-houses, which are drawn into the middle of the fields. The poultry wandering about at will soon free the plants and the soil from all their parasitic insects. It is a very cheap, useful and ready method.[1]

Traps and Baits.—To facilitate the collection of insects and their larvæ artificial shelters fixed on the plants have been tried. The trunks of trees in autumn have been girdled half-way up with undulating cardboard bands of about four inches wide or with bands of straw. All the insects which hibernate as perfect insects take refuge there. All that has to be done is to remove and burn the refuges. This process is of frequent use in Germany to destroy the vermin of fruit trees.

[1] *Translator's Note.*—Neither British farmers nor British gardeners take kindly to poultry, and both would regard the cure as worse than the disease.

Traps fulfil the same purpose as shelters, they draw the insects to a certain point and render them more accessible to destruction. When a polyphagous (omnivorous) insect has a marked predilection for a plant, trap-plants are sown between the lines of the crop. The insects prefer to seek the trap-plant, on which it is easy to collect them or destroy them by energetic chemical means, destroying both the insects and the trap-plant at the same time. The larvæ which ravage the plants in the soil may be destroyed by analogous methods. Fleshy roots or tubers are buried in the soil between the rows of the cultivated plant which are removed when the parasites have chosen a domicile there. *Nematodes* and grey worms, which are polyphagous but have a marked predilection for certain tubers, are destroyed in this way.[1] Lantern-traps are used to destroy winged nocturnal parasites, butterflies, and coleoptera. They form luminous fires which attract the moths at night. Acetylene lamps fitted with a reflector and surrounded with a plate coated with birdlime retains the nocturnal visitors. This process is used in viticulture in which it helps to lessen the Pyralis and the Cochylis. Therapeutical surgery is therefore chiefly used to combat animal parasites.

Chemical Treatment.—Cryptogamic diseases require chemical treatment, for it is a case of overcoming organisms so infinitely little that the eye can often only see them with difficulty.

Curative Treatment.—The chemical treatment consists in placing the parasites in contact with substances which have an injurious effect on them.

Insecticides are used to kill insects; *anticryptogamics* or *fungicides* to combat parasitic fungi. To get the best results from the use of chemical reagents, it is desirable to know the properties of the curative agents and the right method of using them.

Examination of Curative Agents.—The chemical products utilized in the struggle against parasites ought to respond to the following different requirements: (1) To destroy the parasite or arrest its evolution. (2) To be more poisonous to the parasite than to the plant. (3) To preserve their poisonous properties for a certain time and to adhere sufficiently to the organ of the plant. (4) To enter into intimate contact with the parasites or their elements of propagation.

Action of Chemical Products on Parasites.—Most of the chemical agents employed against parasites act chemically on their vital substance. The most active are in general those which form inert derivatives with it, which precipitate the albumen or which modify the plasma; such are corrosive sublimate, formol, copper salts, phenols, etc. They thus arrest, temporarily or definitely, the evolution of parasites or their elements of propagation. In the case of bacteria the phenomena of intoxication may be more easily observed. It is then observed that their evolution and reproduction are arrested by the formation of an inert layer around them. It suffices often by prolonged washing of these bacteria with appropriate liquids to remove the immobilizing layer and to allow them to resume under normal

[1] *Translator's Note.*—As many as 150 wire-worms have been trapped by rape cake, etc., 2-3 inches underground close to one hop hill by Whitehead.

conditions the sequence of their uninterrupted evolution. The chemical agents do not therefore necessarily kill the parasites and their organs of propagation; often they only paralyse for a certain time the normal evolution of the parasite. The more the therapeutic agent is capable of insolubilizing albumen, or of modifying the substances constituting the cells, the more active it is. Wuthrick (" Zeitschrift für Planzen krankeiten de Sorauer," 1892, p. 81) examined the comparative action of various substances on the different spores of fungi. His researches, in which mention is made of the relation which exists between the molecular weight of the chemical products and their action on parasites, leave no room for doubt on the subject of the similarity of the action of various chemical products on the vital substances of parasites. Other poisonous chemical products act on parasites, some in virtue of their properties as solvents of organic matter, such as the caustic alkalies, alkaline soaps in aqueous or alcoholic solution, and certain acids, others by their dehydrating action exerted chiefly on the medium on which the parasite lives. No parasite living in an aqueous medium can develop except when the amount of water contained therein does not descend below a minimum. A disease may be stopped if the conditions of existence of a parasite be modified in this direction. Other chemical products are *asphyxiants:* impalpable powders, and oils and fats; they obstruct the respiratory passages.

Action of Chemical Products on Plants.—The chemical products used to combat plant diseases have all, to a certain extent unless insoluble, an injurious action on plants. The plant is generally less sensitive to chemical agents than the spores of fungi, and more sensitive than insects, their larvæ, and their eggs.

Liquids Spread on the Surface of Plants may penetrate therein by *endosmosis*, whilst gases and vapours do not appear to be, or are with difficulty, absorbed by the plant.

It follows that the treatment of plant diseases may be preferably done—

1. *By products under the form of gas or vapour.*
2. *At a time when the organs which permit endosmosis no longer exist, and when the cellular activity of the plant is reduced to a minimum, that is to say, in winter.*

At that time of the year chemical agents of any degree of concentration may be used without injuring the plant, whilst in summer infinite precautions must be taken not to destroy the organs of the infected plant at the same time as the parasites. Treatment by gas is very efficient, and is becoming more common every day, whether it be the treatment of the part of the plant above ground (aerial), or of that underground, the roots being infected as frequently as the stems by parasites injurious to their normal evolution. With this end in view injections of carbon disulphide, petroleum, benzene are made into the soil, and by enclosing (*clochage*) the part above ground, an atmosphere may be created charged with sulphurous acid, carbon disulphide, prussic acid, nicotine, etc. When solutions or emulsions of the chemical agents are to be used in spring and in summer, the sensitive-

ness of the plant towards these ingredients must be known. Each plant possesses its own particular sensitiveness towards substances poisonous to parasites, and it is desirable to use these substances, in each instance in an appropriate degree of concentration. When the sensitiveness of the plant is greater than that of the parasite, there is reason to abstain from the use of such substances, or it is then necessary to follow the spraying by washing with pure water, only giving them the time required to act on the parasite. This latter precaution allows the use of strong doses of toxic substances, doses which would kill the plants if the washing did not intervene to prevent prolonged contact.

Indispensable Properties of the Chemical Agents.—The chemical agents should be of such a nature as to guarantee reaching the parasites. Certain insects and their larvæ are covered with hair and down, or even with a coat of wax, which prevents aqueous solutions from reaching them. The insecticides which should be employed in such cases are alcoholic, ethereal, or oily solutions, soaps and caustic alkalies having a solvent action on the organs of protection, and capable of moistening them, so as to let the toxic substances penetrate as far as the sensitive organs of the insect. The treatment should often be curative and preservative, and it is then necessary that the substances used should persist for the longest time possible on the surface of the plant. This problem would be easily realized if rain did not remove in a short time the deposit of substances created by spraying. Attempts have been made to protect plants from the effects of the natural washing by the use of substances of poor solubility in water, and with a perfect adherence to the organs of the surface treated. The agents only slightly soluble in water spread on the surface of the plant, in the form of *bouillies*, form deposits which the rain cannot remove owing to their own adherence, or to an adherence acquired artificially, by the incorporation of gluey substances, insoluble in water (silicate of soda, saccharates, soaps, gelatine, rosin). But care must be taken not to use too insoluble substances and in too great quantity, for there is a risk of covering the whole of the respiratory surface of the leaves with a layer rendering the exchange of gases impossible, which, if it does not cause asphyxia, produces at least an annoying disturbance in the growth (evolution). The insoluble, or the only slightly soluble products are, in general, of greater service than the soluble products. In addition to their less injurious action on the plant, they persist longer on the surface of the vulnerable organs and their action is of longer duration.

The insoluble products are intended to poison insects through the stomach. A slight layer of arseniate of lead, or of arsenite of copper (Paris green),[1] on the leaves penetrates into the stomach at the same time as the leaf and kills the insect. In the case of cryptogamic parasites, slightly soluble substances are used, which in contact with the dew causes it to become toxic, owing to the traces of poison which it has dissolved, and to kill the spores, which require its aid for their evolution. Briefly, it is necessary in each particular case to choose

[1] *Note by Translator.*—Arsenite of copper is not Paris green but Scheele's green. Paris green is our emerald green, the aceto-arsenite of copper.

the appropriate remedy and to use it with discretion. It is the most difficult side of vegetable therapeutics. The therapeutic store contains a great number of products the action of which is analogous. Those which can be usefully employed can be reduced to a small number. The most interesting are carbon disulphide, bouillie bordelaise,[1] lime, sulphur, sulphate of iron, sulphuric acid, emerald green, soap-emulsions of petroleum and alcohol, tar, prussic acid, tobacco, and nitrobenzene. The greater number of the chemical products which have been the subject of experiment against the diseases of plants are, nevertheless, dealt with in this treatise, and deductions drawn from the aggregate of the results obtained by the experimenters. The results which have been published are so very different, and the opinions expressed so contradictory, that the author has been obliged to control the facts by personal experiment before expressing an opinion. Laboratory experiments do not always permit of the conclusion that their results will be confirmed in actual practice; parasites have natural means of protection which are awanting in the laboratory, but which enable them in a natural state to escape very often from the deadly action of the agents used. Experiments, therefore, to which most weight is attached are those made in practice. According to their mode of action and their nature, chemical agents are used and applied in very different ways.

Methods of Using Chemical Products in Treating the Diseases of Plants.—Insecticides and anticryptogams are used in three forms: (1) As gas. (2) As powder. (3) In the state of solution or suspension in a liquid vehicle. *Use of Chemical Agents in State of Gas.*—Gases are used in closed spaces under a *cloche*[2] or in the soil. For this purpose there is utilized either liquids which evaporate at the ordinary temperature or solid products which disengage gas by heat, combustion, or chemical decomposition. In any case it is necessary that the gas mix perfectly with air and reach all the corners of the area to be disinfected. In closed spaces that is comparatively easy, in the soil it is more difficult to realize.

Underground Treatment.—Injections of volatile liquids are made in the soil at suitable depths by means of an instrument called the *pal injector* (fig. 5, p. 63), when by sprinkling the soil with water the gas which is disengaged is enclosed. When such treatment is carried out with the necessary care, so as to avoid the contact of the liquid substance with the roots of the plant it yields perfect results. But difficulties are encountered due to the nature of the soil. If it be easy to disengage toxic gases in a friable soil it becomes difficult to spread the gases uniformly in a compact wet soil. Gases circulate with difficulty through certain soils, and are not retained long enough in others. Water creates an impenetrable barrier to the circulation of gases.

[1] The translator has retained the original French term throughout. The usual English rendering of the term as "Bordeaux mixture" being, in his opinion, a poor rendering. All bouillies are perforce mixtures, but only a few mixtures are bouillies.

[2] *Note by Translator.*—A bell- or dome-shaped glass vessel familiar to those who dab le in the French style of gardening recently resurrected in Great Britain but well known to London market gardeners at least 150 years ago who even in those early days used them by the hundred.

The gases produced in the soil should not enter into reaction therewith and be fixed by the substances in the soil. From this point of view carbon disulphide is the best substance. Other substances, such as tar, petrol, benzene, sulphuretted hydrogen, are retained by the capillarity and chemical action of the soil which often energetically opposes their distribution. To avoid failure it is well to give the preference to insecticides in dilute solutions in winter, and to volatile insecticides in summer, when the soil is dry.

Aerial (or above ground) Treatment by Gases.—*Clochage*, or treatment in a closed space, gives the most certain results, and does not exert an unfavourable influence on the development of the plant. Highly poisonous gases may be used against parasites, because they do not generally have a deadly action on the plant, especially when contact with the plant is not prolonged beyond measure, which result is obtained by aerating after a predetermined time.

Clochage is used to disinfect the vine by sulphurous acid. The stock is covered with a *cloche* made of a tun (cask) cut through the middle, or with a zinc receiver fitted with two handles. Under the *cloche* the gas is disengaged by combustion or by chemical decomposition of certain salts: sulphur is burnt, or potassium cyanide is decomposed by sulphuric acid. The operation is finished in ten minutes. In greenhouses or in closed spaces made around fruit trees or against espaliers with waterproof awning, the operation is performed in the same way. In all cases where disinfection by gas is possible, it ought to be applied as a process sure to disinfect without injuring the plant treated. It is the only process applicable to food warehouses. Treatment by gas is always curative. When this treatment is not applicable recourse is had to treatment by boiling water, or solutions of toxic substances, emulsions, or pulverulent products.

Scalding or treatment by boiling water finds a very extended use in winter to kill by heat all parasites and their germs lodged along the trunk of a plant. But that is a winter treatment which cannot be applied in summer, the delicate organs of the plant not being able any more than the parasites to support contact with hot water.

Use of Chemical Agents in the Form of Powder.—Non-poisonous but asphyxiant powders are used such as they are; toxic powders are reduced more or less according to the intensity of their insecticidal or sporicidal capacity with flour, talc, chalk, or any other inert matter, finely divided and cheap. The powders are projected on to the plant by means of bellows called sulphurators (figs. 3 and 4, p. 47). Powders may be projected where liquids cannot penetrate. Liquid treatments are sometimes alternated in the struggle against stubborn diseases with pulverulent treatments of the same composition.

Use of Chemical Products in the Liquid Form.—Poisonous substances in a state of solution are used in both the external and internal treatment of plants. In the external treatment the poisonous substance is spread on the plant, whilst in the internal treatment it is introduced into the juice, either by causing it to be absorbed by the roots or by injecting it into the trunk. External treatment is most

generally used, and it is from it that the most successful results are to be anticipated.

External Treatment: Liquids.—Solutions, bouillies, emulsions are much more used than gases and powders owing to their easy use. These preparations are distributed by the spraying machine (figs. 8-12) when the treatment is general, and by the brush when it is local. The efficiency of the treatment by liquids depends to a great extent on the mode of application. The substances should be projected in a finely divided state, best in the form of a mist, because it is less important to accumulate large quantities of substance in a given point than to spread a little everywhere in a uniform manner, above as well as below the leaves, on the twigs and on the trunks. The largest number of points of contact between the spores of the fungi or the insect and the poisonous solution must be secured. The appliances which attain this object are the spraying machines which have reached a high degree of perfection. The liquid preparations must possess a certain degree of concentration to be active. It is injurious to increase this concentration, and dangerous to diminish it. When a liquid preparation has a poisonous action on the plant, or if it has no adherence, these drawbacks may be obviated by multiplying the treatments with a weaker preparation. It has been found that it is better to diminish the strength of the applications and to increase the number of sprayings, for it is the abundance of these rather than the strength of the preparation which forms on all the organs, in proportion as they are developed, an extremely thin layer of a toxic substance capable of preventing the development of spores or of poisoning parasites.

Experience has proven that periodically spraying at short intervals with weak bouillies yields far better results than a single annual spraying with concentrated bouillie as formerly practised. The single spraying with a 4 per cent copper sulphate bouillie used some years ago has been replaced by three to seven treatments with bouillies prepared with 0·5 per cent of copper sulphate. Although the total amount of copper spread on the surface of the plant be mostly less than formerly, the result is better, because all the surface of the plant remains covered with a very thin pellicle of hydrated oxide of copper of which a trace dissolved in rain water or dew suffices, as has been found, to kill the spores which are germinated. This new process is the more efficient because it especially guarantees against disease all the young organs of the plant, which being more tender and more aqueous, are more easily invaded by parasitic fungi and have therefore a greater receptivity for cryptogamic diseases. The perfection of the treatment is, therefore, an element as important to secure success as the properties of the product. When anti-cryptogamic substances are used, it is necessary to bear in mind that the external treatment of a plant cannot destroy the mycelium of the fungus which has penetrated into the plant, and its multiple ramifications in the interior of the latter are perfectly protected from all outside spraying. The external treatments are intended to destroy the organs that disseminate the disease, the conidiophores and isolated spores, and thus prevent the extension of the disease to other plants. If for any reason the treat-

ment has been deferred and the disease has assumed a great extension, it is well to remove before spraying the parts of the plant most seriously attacked and to burn them; that is a surgical complement to the chemical treatment which may be of great service and which must not be neglected if one be anxious to suppress the disease. It is well to say that neglect of one factor may compromise the results of the treatment by liquids and rob the experimental effort of any beneficial result.

Internal Treatment.—From analogy, with the treatment of human diseases, attempts have been made to introduce into the sap of the plant toxic elements, intended to be carried through the plant, and to destroy the mycelium of fungi which have invaded it, or to kill xylophagic insects and those which suck the sap. The experiments of Laffitte and Henneguy have shown that a substance dissolved in water, absorbed by the roots, may ascend to the leaves and reach the extremities of the tree if it does not form insoluble compounds with the constituent elements of the sap; however, the greater number of salts yield with the plasma insoluble derivatives, which prevent their entrainment by the sap towards the part of the plant attacked by the parasites. Numerous experiments have been made in this direction to combat the phylloxera. The method used, it must be confessed with mediocre success, consisted in making a hole in the vine stock from above downwards by a gimlet, and in introducing therein the chemical agents such as calomel, camphor, potassium sulphide. These were the first experiments carried out under very bad conditions, nevertheless carbolic acid, used by Green against lice, prussic acid against bugs, have given appreciable results. The first fortunate results were obtained by Mokretzki with injections of a dilute solution of sulphate of iron, and nutritive elements which he injected into the sap to cure chlorosis. These were crowned with complete success. But they must be executed in such a way that the air cannot penetrate into the wound, and a slight pressure is required to enable the liquid to enter into direct contact with the sap of the plant. However, when Mokretzki tried sulphate of copper under the same conditions, his experiments were a failure. It is possible, however, that organic salts of copper soluble in the sap may behave as indifferent salts, especially if used in small doses, and produce the satisfactory effects on the health of the tree given by dilute solutions of sulphate of iron, and by sprinkling the soil with sulphate of copper. Metals are capable of forming organic salts, which no longer precipitate albumen, and, injected into the sap, may behave in quite a different manner from the corresponding inorganic salts. These organic salts have found multiple applications in human therapeutics, and it is to be supposed that their use will extend in the domain of vegetable therapeutics. The internal treatment discovered by Mokretzki will perforce extend further when it has been determined under what form poisons can be incorporated with the sap, and especially in what degree of concentration they should be used. These remedies will form a powerful instrument against all sucker-lice, and will be capable of arresting the internal evolution of the mycelium of parasitic fungi.

But vegetable therapeutics will often yield imperfect results in spite of all the attention brought to bear in the application of appropriate remedies, for it is difficult to dislodge or to destroy in the interior and on the exterior of a plant without injuring it the parasites which develop there, surrounded by the very efficient means of protection which nature has given them; and if we insist on this axiom, that a plant disease cannot be cured, but that it can only be diminished or its extension prevented, the important rôle which preventive methods play in the struggle against plant diseases will be understood.

Prophylaxy.—Prophylaxy is that part of medicine which deals with the means of guaranteeing against disease and preventing it. Knowing the cause or the causes of the diseases it is possible to protect plants efficiently against them. The knowledge acquired as to the reactions of the organism, and the means by which it naturally arranges to defend itself against disease, have enabled prophylaxy to utilize physiological processes instead of agents destructive to parasites. It is necessary to differentiate between therapeutic prophylaxy and hygienic prophylaxy. The former utilizes therapeutic agents, surgical processes as well as antiseptic insecticides, fungicides. The latter employs dietetics, stimulants of growth, rational feeding, selection of vigorous and hardy species. Medicine in its application to plants is in fact as complicated as when applied to man, and it is not surprising to see it necessary to take at the same time prophylactic and therapeutic measures in order to have crops free from disease.

Therapeutic Prophylaxy.—When the cause of a disease is known, its evolution and that of the parasites which produce it, it is comparatively easy to find the means of checking it by preventive measures. These treatments may be very often carried out at a time when the plant can bear them with impunity; in winter when the delicate organs have disappeared and when the sap is at rest. One must never wait until a disease manifests itself, even if the possibility of its appearance is not absolutely certain. Preventive treatments if they are not always capable of removing all the effective and adjuvant causes of disease will minimize them. When the cause is a parasitic one, the object pursued is not to destroy all the parasitic elements, but to reduce them to their normal or natural number increased by our methods of cropping. In these conditions, parasites having always existed and their complete destruction being as chimerical and as useless as a complete disinfection of the air which we breathe, with the object of destroying all microbes, disease is no longer to be feared, because it no longer causes us appreciable injuries.

Preventive Surgical Treatments.—Operatory medicine may be of great assistance in the prevention of plant diseases; in fact the suppression of everything which may transmit a disease from one year to another is often capable of giving radical results—excision of the diseased parts, removal of branches attacked or bearing spores or eggs, washing of the bark of the trunk and branches to suppress refuges formed by mosses and lichens for acari, aphides, and coleoptera. Intervention by naked hand plays a rôle not less important, by the collection and suppression of the old organs of plants, leaves, and

rotten and wormy fruit on which receptacles containing the spores of fungi serve as refuge to grubs and chrysales and as shelter to masses of insect eggs. The destruction of the parasites and their hiding-places by this simple means causes them to disappear completely after a certain time.

Birdlime traps preventing insects and their larvæ from reaching points that they might ravage, are likewise useful auxiliaries. The most usual trap is the ring of tar or of birdlime with which the trunk of trees is surrounded. The going and coming of apterous parasites between the leafy portion and the soil being along the trunk, the ring of sticky substance drawn round the trunk is intended to stop these often daily journeys and to retain all these parasites stuck fast. An examination of the habits of parasites demonstrates that almost all are forced to use this road; some to seek a refuge in the soil for the night, others to ascend nightly from the soil in which they had taken refuge during the day. Thus the grub descends along the trunk to place itself as a chrysalis in the soil, and the butterfly, even when it is not apterous, ascends along the trunk to deposit the eggs which weigh down the female. The grey worm and many moth grubs go every morning to find a refuge in the soil, to re-ascend the trunk in the evening. This method, now very common, gives perfect results. In arboriculture it is a powerful auxiliary to the liming of the tree, but it is necessary to watch that this sticky substance preserves its adhesive qualities and to renew the ring when these have disappeared. Young fruit trees being sensitive and liable to perish after an application of a ring of tar or birdlime, it is well to fix round the trunk a strip of cardboard well fitted and to coat it with the sticky substance. The same result is thus obtained without injuring the health of the tree.

Preventive Treatment by Means of Chemical Agents.—The general conditions as regards the properties of the chemical agents used in the preventive treatment of plant diseases are the same as in the curative treatment. The chemical products must destroy the parasites and be more poisonous to it than to the plant; they must adhere and preserve their poisonous power for a certain time, and enter into intimate contact with the parasite or with its elements of propagation. When such treatments are applied, as is often the case during the repose of vegetation, the comparative insensibility of the plant enables them to be used in doses, deadly to the parasite without injuring the plant. Most fungi living protected in the interior of the tissue are sheltered from the action of the poisons spread on the surface of the organ attacked, and are evolved in spite of the curative chemical treatment. The important point in plant diseases is to destroy the spores which propagate the disease. To attain this result, different spores must be attacked by different methods. If it be a case of destroying winter spores, very energetic treatment must be applied in winter, for these spores have an extraordinary power of resisting chemical agents. If it is a case of killing summer spores, which, on the contrary, are very sensitive and delicate, a treatment with dilute, anticryptogamic solutions will suffice. Preventive winter

treatment can thus be distinguished from preventive summer treatment. Preventive winter treatment consists in destroying by chemical agents all parasites, and the elements of their propagation. To obtain this result the trunks and branches are painted or washed, after a mechanical dressing with milk of lime, concentrated copper bouillies, 10 per cent solutions of sulphuric acid, hot concentrated solutions of sulphate of iron, boiling water, petroleum, and pure carbon disulphide. These chemical agents, used in such a high degree of concentration, do not injure the plant in winter, and permit of a radical destruction of the parasites. These preventive winter treatments are, generally, sufficient to prevent the diseases from appearing in the following year, especially when care is taken to destroy the decayed organs scattered around the plant, and to disinfect the soil, the dung, and the seed. This last precaution is of an undoubted utility in preventing the diseases of plants cropped annually, and the methods usually employed have now attained a great degree of perfection. Moreover, it is necessary to destroy wild plants of the same species, which are preferred by the parasites which it is desired to destroy, plants which form seats of infection which are necessary to the cyclic development of certain parasitic fungi, such as the rust of cereals, which search for nurse plants of different species necessary for their normal evolution, and the destruction of which brings about the radical suppression of the parasite. These plants are the barberry and boragineæ (* p. 22).

Preventive Summer Treatment.—In spite of preventive winter treatments they must be completed by summer treatments. Working so that the vulnerable organs of the plant are always protected by a fungicide very slightly soluble in the dew, the plant is prevented from succumbing to the incessant attacks of the spores, which the atmospheric currents lead to it. It is a case of very small doses of anticryptogamic agents, which suffice when the treatment is continued during the whole period in which the disease is to be feared. Weak injections of carbon disulphide in the soil and periodic washings of the stock with dilute solutions of potassic sulpho-carbonate have given the best results in the struggle against the phylloxera, without destroying all the parasites they so far diminish their number that they can no longer injure the plant. Sulphating every year with weak bouillies yields analogous results and enables the trees to develop normally. Along with the rational and periodic use of chemical agents intended to kill the greater part of the germs of cryptogamic diseases and insects, it is well to use stimulants to furnish rational nutriment to the plants and to pay attention to their hygiene.

Hygienic Prophylaxy.—Vegetable therapeutics does not consist, in fact, entirely in the struggle against the effective factors, but it ought likewise to suppress the adjuvant causes. Plants are restored like animals by the art of healing regarded in its widest scope. Hygiene which plays so great a rôle in human prophylaxy ought to receive equal attention in the case of vegetables. This hygiene is based on a knowledge of their organs, and their mode of growth, on that of the environment where they live, and the climatic conditions which favour their development, and the mineral elements indispensable to

them. It is necessary to remove bad influences from plants, and to supply them, if need be, in a regular and abundant manner with the nutritive elements which they require. If it be asserted that a disease can be transmitted to a plant by artificial infection when placed in a laboratory where it has not all its means of reaction, it must not be concluded therefrom that this same plant will always succumb to this parasite in surroundings favourable to its development and in good hygienic conditions. Owing to a special immunity which is not acquired, except under certain conditions, the plant, on the contrary, will be able to resist the attempts of invasion by the parasites and will issue victorious from any struggle in all instances.

Most cryptogamic parasites are incapable of attacking the living vigorous and healthy cell. Certain insects, even xylophagic, such as the Scolytes, only attack a sickly tree, the intense motion of the sap being injurious to the development of their larvæ. On the other hand, most parasites find an easy shelter in the plant when the latter is enfeebled by an adjuvant cause, or when organs capable of being invaded have been laid bare by a wound.

Stimulants of Growth.—We know from the researches of Raulin, Nageli, Pfeiffer, Richard, and Ono the favourable influence which certain metallic salts absorbed by the sap can exercise on the health of plants. Salts of iron, copper, mercury, zinc, nickel, cobalt, manganese, lithium, fluorides, and arsenites have in a certain dose a stimulating action on the vital functions of the plant, analogous to that which arsenious acid exercises on our own organism. The use of these stimulants may often be a useful means of stimulating the vigour of the plant, and of rendering it more capable of resisting cryptogamic diseases.

Nutrition.—The researches of Liebig, Boussingault, Deherain, and others have shown that the development of plants depends greatly on the mineral elements which they find in the soil, and nothing is more easy than to supply them when the soil is deficient therein. The result of these researches has been intensive farming, which by supplying in great abundance the elements necessary for the growth of plants has rendered it possible to double and triple the yield of crops. Encouraged by such success we have learned to prepare an exact account of the elements indispensable for each plant crop by the analysis of its ash, of the elements of the soil, and taking into account the nutritive elements that the preceding crop has removed and adding to the soil the elements in which it is deficient. It has been observed, however, that the plants obtained as a result of intensive manuring were more subject to diseases, and that such assumed a dangerous character. The great delicacy of the plants constituted a more favourable medium for their evolution, however little the climatic conditions favour their development, and predispose the plants to infection. It must be admitted that the intensive culture now practised does not produce a normal condition of the plant, but a cultivated condition, and that the parasites have acquired a greater vigour and become more virulent owing to the great richness of the plant in nutritive

elements. Too abundant feeding of our cultivated plants has created a danger which the farmer of to-day must face.

Formerly the method of cultivation gave a mediocre and irregular yield, and the farmer did not disturb himself. There was in the opinion of our fathers, which was fatal, good years and bad years. Diseases existed even then, but they did not in their opinion contribute much to the annual variation in the yields. In our days they have a much more important rôle, for the cultivation expenses being higher, owing to increased attention and to the use of various chemical manures, the yield ought to compensate for the pecuniary efforts expended.

Exhaustion of the Soil.—In spite of the annual supply to the soil of the elements required by the plant for its intensive growth, it is found that a time comes when the plant ceases to profit from the nutritive elements and thrives no longer. This is due to the fact that the enemies of the cultivated plant are accumulated in the soil. The ancient farmers attributed this condition to the exhaustion of the soil, and intercalated the *bare fallow* between the crops when this exhaustion manifested itself. In bare fallow the fields remained several years without a crop. Without being aware of it they thus abolished the provision stores of the parasites, and these disappeared or became reduced to their natural proportion. By this time the field had acquired new vigour, and might be again cultivated. This method cannot be adopted to-day, because it is a loss of time and money. The alternation of crops or of different plants having consequently different parasites succeeded each other, and where the same plant did not appear in the rotation except at long intervals it caused a great improvement in this condition of the soil. Rotations would give perfect results in the absence of polyphagic parasites : Nematoides, Elaterides, grey and white worms which attack all our crops indifferently, and the exaggerated multiplication of which operates throughout the most different crops; the spores of *Ustilagineæ* (smut, bunt, etc.), which resist the weather for several years, excepted. Against the exhaustion of the soil from the exaggerated development of these parasites no efficient remedy exists, except disinfection of the soil by carbon disulphide. This must be done either in a complete manner, and in massive doses every ten years, or in small doses each autumn. It frees our cultivated fields from all the parasites which our methods of cropping have allowed to accumulate in too great number. This method finds more adherents every day, as it enables rotations to be dispensed with and to cultivate the same plant intensively for several years in succession. Artificial manures as well as the metallic salts intended to stimulate the growth of plants should be used with discretion, so as not to predispose the plant by a modification of the sap to certain diseases which formerly it escaped. Laurent found that bacteria, not parasites of the potato in a normal state, might invade it after manuring with lime. The Jerusalem artichoke becomes less resistant to the *Sclerotina Libertiana* [1] after phosphatic manure. These

[1] *Note by Translator.*—Fungus which ravages potato, haricot beans, hemp, cucumbers, swedes, zinnias, petunias, chrysanthemums. *Remedy.*—Apply soot or lime to soil.

two cases are easily explained, the first by the fact that the bacteria seek an alkaline medium created by the lime, the second by the fact that the *Sclerotina* seeks, on the contrary, an acid medium created by the acid phosphate. Intense nitrogenous manuring favours the development of phytophora. It is thus essential to avoid the use of manures which may place the plant in a state of subjection in the struggle which it has to sustain against inimical factors.

Choice of Species.—One species may be more subject to disease than another, and possess a predisposition for certain pathological conditions. That occurs when the conditions favourable to the development of the plant are also those which favour the evolution of parasites at the time when the plant is young and possesses delicate tissues just when the parasites are most virulent. Care must be taken in sowing a plant that the germination of the seed does not coincide with the virulent development of the parasite, with the ripening of the spores of fungoid enemies, or the hatching of the eggs of certain insects. It suffices to sow a little earlier or later. But in spite of all that can be done to eliminate parasites, they none the less exist and ravage the tissues. The cells of the plant, like those of the human organism, react, and it is found that after this constant struggle they undergo certain modifications which are opposed to the development of the parasite, and the plant acquires a certain immunity. It is acknowledged that the deposits of tannin and other materials in certain cells and the concentration of the sap are conditions resulting from the struggle of the plant against insects, and destined to oppose an unsuitable medium to any attempt of development. Plant diseases do not, therefore, depend solely on the presence of a parasite, but as much on the conditions predisposing the plant to a want of reactive energy, and it has been found that this predisposition was an attribute of certain species or certain varieties.

Meteorological Influences.—Although we are still badly equipped to struggle against atmospheric influences, each day brings new discoveries from which agriculture knows how to benefit. Thus hail and morning frosts may be effectively prevented—hail by artificial percussion of the atmospheric layer where hail is formed, morning frosts by means of artificial clouds. Without neglecting therapeutic methods it is necessary to take incessant prophylactic measures to prevent the evolution of diseases and their propagation, to treat the seed, the plant, the soil, and the crops by toxic products, to destroy the plants invaded, which form hot-beds of infection, to avoid the importation of plants from districts notoriously infected. Effort must be made to apply a general treatment to the plant, to remove as far as possible all conditions favourable to the growth of parasites. The hygiene of the plant must receive careful attention; sowing retarded or advanced; the plants protected against eventual frosts and hail; drain and lime the soil against humidity, the great predisposing cause of cryptogamic diseases; apply appropriate strengthening manures; choose hardy species obtained by crossing or by selection, and create new varieties combining great resistance to plant diseases with the necessary properties of production. So that the struggle may be suc-

cessful measures must be general. Each cultivator ought to be able to work in full knowledge of the cause ; he ought to be able to obtain information on the nature of the diseases which he observes, and the means which should be used to combat them. All interested should be able to act simultaneously over a large extent of territory, a condition which will alone crown any individual effort with success. There now exist in certain agricultural centres laboratories where all questions are solved gratuitously. These institutions are intended to help cultivators, and to supply them with the means of combating the diseases which ravage or menace their crops. The movement in favour of these institutions where all phytopathologic questions are studied, and which centralize all the observations made by interested parties on the diseases, the presence of which they have observed, is especially accentuated in Germany. When the prosperity of a country is threatened by the appearance of a disease and by its generalization it is necessary to take general measures. These are made imperative in many cases on cultivators by *arrêtés* [an arrêté is possibly equivalent to our Order in Council].

If one considers that the damages caused annually to French crops by injurious insects, according to the calculations of authorized persons, amount to several hundreds of millions (a million francs = £40,000), that the loss due to cryptogamic disease reaches a still higher figure, an idea can be gained of the great necessity there is to generalize the methods of struggling against parasites, and the necessity of simultaneous action by all under the control and the direction of official agents. The first order dealing with the protection of crops against injurious insects is that of the Parliament of Paris of date 4 February, 1732 ; then came the Act of the 26th Ventose Year IV, which rendered obligatory the destruction of grubs in general (modified by the Act of 24 December, 1888). It especially prescribes the destruction of the grubs of *Liparis chrysorrhea*, the brown-tailed moth, the agglomerations of which in winter and in spring form silky wrappers between the branches of fruit trees. The Order declares that "After the date fixed by the Prefect, farmers who have not submitted to the prefectoral order, will be liable to a fine of six to fifteen francs, and obliged to pay to the administration the expenses incurred by it in grubbing on their domains". The panic created by the appearance of the phylloxera in 1863 was followed by an effect which has made itself felt in all branches of cultivation. Examination Commissions were formed, a National Agronomical Institute was founded in Paris. Chairs of Agriculture were created, new laws were passed, the Administration is working with equal solicitude at all cultural pests, and it has enacted the measures required to cope against the extension of diseases. As a consequence of the International Phylloxeric Convention held at Berne, an order of 10 September, 1884, interdicted the exportation and importation of rooted-up stocks and of sprouts (shoots). Then the destruction of insectivorous birds has been forbidden. Cultivators too often misconstrue their precious collaboration in the struggle against parasites.

Societies for the destruction of parasites have been formed in

cantons, bureaux of gratuitous information opened, enabling interested parties to know the disease which ravages their fields, and how to prevent it, or combat it, in the most economical conditions. These syndicates are cantonal or communal; their bye-laws must have prefectoral sanction; their budget consists of the subscription of adherents, individual subscriptions, communal, and Government grants. The Council of Administration places the instruments, the insecticides, and the anticryptogamic products at the disposal of those interested; it publishes the right times to use preventive or curative processes, and gives the detail of the methods to follow; it directs itself at propitious seasons all the operations tending to the destruction of parasites, and to restore the fertility of the fields through the intermediary of an executive committee which has the direction and the responsibility of operations. Societies have been formed against the "Apple-blossom Weevil," against the may-bug (cockchafer, *Hanneton*). The annual results obtained by some may-bug societies in a year are as follows:—

Seine et Marne .	destroyed	282,500 kilogrammes.[1]
Brie Comte Robert	,,	101,000 ,,
Aisne . . .	,,	13 thousand million cockchafers.
Bernay dans Eure	,,	148,500 kilogrammes.

These figures are eloquent. However, if they show the useful intervention of the syndicates established for the destruction of injurious insects, they enable us to foresee the results that these syndicates would be capable of obtaining if their programme was a broader one, and comprised all which concerns vegetable pathogenesis, prophylaxy, and therapeutics. Common action organized in this way under wise direction will be a perfect method to combat agricultural pests and blights so long as no medical specialists for cultivated plants, with the same rank as veterinary surgeons, exist. But there is much ground to be traversed before getting so far as that; the science which should guide these medical specialists is only in its infancy, and the most important problems are still to be solved. It is, however, necessary to reach this goal so that this younger sister of medicine applied by special practitioners may render inestimable services to cultivation and increase the prosperity of the country.

[1] *Note by Translator*.—From the peculiar style of numeration of French writers it is impossible to say whether 282,500 means 282½ kg. or 282,500 kg., that is 282½ metric tons, which seems impossible. Yet even in this country so great were the ravages of *Bombyx chrysorrhea* in 1782 that prayers were offered up in some churches for deliverance from the scourge and 1s. per bushel was offered for the webs, and so abundant were they in Clapham parish that 80 bushels were collected in one day in that parish alone!

* *Note by Translator* (p. 17).—The tendency of present-day authorities is as regards evolution of rust of wheat to discard the theory of an intermediate host (barberry) in favour of Eriksson's theory of hereditary infection.

CHAPTER I.

COLD WATER—SUBMERSION—SPRAYING HOT WATER—IMMERSION—SPRAYING—HYDROGEN PEROXIDE.

1. **Water,** H_2O.—Water is necessary to the plant (1) as food, (2) as solvent of nutritive matters. To a certain extent crops increase in proportion to the water used in the cultivation. Want of water injures the plant, causes deformities, anomalies, and troubles of which the chief are: *pilosis*, excess of hair on the stem and leaves, formation of tart substances (piquants), stony pears, lignification of the roots; *nanisme*, potatoes with filiform rhizomes, fall of flower-buds, premature drying of the leaves, honey-dew, barren flowers in the case of cereals. But on the other hand, if water is useful and even necessary to the plant, in excess, however, it is injurious thereto. In the latter case it is the cause of the following diseases: *frisolee* of the potato, rhytidome of the potato, germination of the same plant before potato lifting, hollow fruits, stems and roots, premature formation of seeds, dropsy, gourmands, hypertrophy of the roots, cellular rottenness, frondescence, phyllodia or chloranthia, asphyxia of the seeds and roots, putridity of the seedlings.

Use.—Water serves as a solvent or vehicle for most of the agents used to combat plant diseases; but it can by itself alone serve as an insecticide in many cases, and as it is cheap it is profitable to use it. Cold or hot water is used as follows, according to circumstances: *Cold water :* Submersion; spraying. *Hot water :* Immersion; spraying.

(a) Cold Water, Submersion.—Submersion or artificial inundation asphyxiates the insects living or refuging in the soil. It consists in placing the area of the ground to be treated under water for a period of from two to sixty days, according to the nature of the soil and the kind of parasites to be destroyed. The soil must only be slightly permeable, the ground must not be on a slope, and it must be near a source of water capable of furnishing 6000-30,000 cubic metres per hectare ($2\frac{1}{2}$ acres), and to maintain it at that for a certain time. Submersion is not efficient unless it be complete, so that it may soak deeply into the inundated ground and be executed under certain conditions. The submersion of fields and vineyards is in use in different countries of the globe, and everywhere gives encouraging results. The costs of submersion are not great when near a river from which the water can be led; the expense in that case only amounts to 41 francs per hectare, say 13s. per acre. But when the water has to be brought by elevating machines then it may amount to 200 francs (£8) per hectare, say £3 4s. per acre. To this amount must be added the cost of manuring,

which must be abundant as the immersion exhausts the soil. Submersion was recommended for the first time in France in 1864 for the destruction of insects in meadows and fields. In 1870 the same treatment was applied to vineyards attacked by the phylloxera, and lately it has been used to render forests wholesome.

Submersion of Fields and Meadows.—The inundation of meadows and fields destroys the larvæ of Coleoptera (beetles, weevils, etc.) and the grubs of the Lepidoptera, of which the following are the most important: (1) *Melolontha vulgaris* (white worm), larvæ of the may-bug (cockchafer).—Artificial inundations have been in general use in Hungary since 1888 to destroy this larva. The meadows are submersed for eight days, and after that time all the white worms have disappeared. De la Blanchere has, however, seen water remain more than a month on ground infested with white worms without these being destroyed. That is explained by the fact that the larva of the cockchafer, very sensitive to moisture, to avoid contact therewith buries itself at such a depth as protects it from inundations. But it is only in impermeable ground that the white worm has the time to withdraw itself from the action of water. In such ground recourse should not be made to artificial inundation but to carbon disulphide. During the two years of its evolution, the white worm descends into the soil in October, to a depth of about 2 feet, so as to pass the winter, beyond the reach of cold, and it is only in spring that it ascends to the level of the roots to gnaw at them. According to the habits of this insect it is, therefore, in spring and in summer that the ground should be flooded. (2) *Phytonomus punctatus*, Fb.—The larvæ of this weevil are destroyed by flooding almost at the very outset. In America the cotton plantations are flooded to destroy the numerous parasites in the soil. (3) *Agrotis segetum*, W.V. (grey worm grub of the dart moth).—Flooding to destroy this insect ought always to take place in summer. In many cases flooding of the fields by the excess of moisture exerts a vexing effect on plants by retarding the ripening of the crops, or by developing adventitious plants or parasitic fungi. It is not so, however, with all crops, and it has been observed that submerged beets have more vigour and resist the fungi which ravage them better during drought, such as the *Phoma tabifica*, the disease of the petiole of the leaves, the *Pleospora putrefaciens* or the heart rot, and the bacillus of the *bacillary gummosis* of vine. These diseases being less intense after submersion the method is advantageous.

Submersion of Forests.—Anderlind has shown the great service which the submersion of forests can render in the destruction of the insect ravagers of woods, the larvæ of which find a shelter under the moss and humus surrounding the stocks. In the different countries where submersion is in use the most dangerous insects only occasion insignificant damage, it is therefore one of the most powerful preventive measures against great invasions of certain forest parasites. The following insects are destroyed by submersion: *Melolontha vulgaris*, L. (common cockchafer). Weevils injurious to conifers: *Hylobius Abietis*, L. (large spruce fir weevil). The Scolytides so injurious to deciduous

trees: *Hylesinus ater*, F.; *H. opacus*, Er.; *H. augustatus*, Hb.; *H. cunicularius*, Kn. The *sawflies*, very injurious to coniferæ, because their larvæ not only attack the adult needles but prefer to devour the young shoots: *Lyda campestris*, L., and *L. pratensis*, L., the larvæ of which bury themselves in August in the moss at the foot of trees to pass the winter there. *L. erythrocephala*, L. (red-headed Lyda), the larvæ of which hide at the foot of trees in the month of June. *Lophyrus Pini*, the larvæ of the second generation metamorphose into grubs in the humus of the forest after passing the winter there. *Gryllotalpa vulgaris*, Latr. (mole cricket). Winter submersion has little action on it, because like the white worm it descends deeply into the ground at the approach of cold. The following Lepidoptera: *Lasiocampia Pini* (or bombyx of the pine), the grub of which hibernates as chrysalis in moss at foot of tree. *Trachea piniperda* and *Fidonia piniari*, L., both hibernating in ground in the state of chrysalis. Submersion also frees the forest from the rodents which undermine it, and which in winter nibble the bark of young trees. But if on the plain the difficulties of submersion are not great, on the slopes where it is necessary to trace a series of parallel channels which flood the ground, by overflowing, this method becomes very costly, especially if it is necessary to raise the water by means of turbines or pumps.

Antiphylloxeric Submersion.—In the beginning of the phylloxeric invasion in 1868, the sands of the dunes (sandhills) were found to be unfavourable to the propagation of this dangerous homoptera. The fact was observed at Aigues-Mortes, where vines planted in the dunes remained flourishing, whilst those planted in the neighbourhood died without exception. According to Foëx the sands exhibited a certain immunity to the phylloxera when they contained at least 80 per cent of silica, but a small amount of clay or limestone sufficed to deprive the soil of this precious property. This immunity, studied by Vannuccin at the viticulture laboratory of Montpellier, would appear to be due to the asphyxia produced by the water retained by capillarity between the grains of sand. Is that water sufficient to cause the asphyxia of the insect; is it not rather the physical constitution of the sand which hinders the passage of this insect from one stock to another? That is a point which has not yet been proven. Balbiani disputes the theory of the asphyxiant action of water in permeable ground consisting almost exclusively of silica; he has in fact caused young phylloxera which he had hatched in a sand medium to live under water for fifteen days. On the other hand, Faucon has observed that it takes forty-five days' immersion in water to kill the phylloxera. Now, sands are never impregnated so long by rain-water. Be that as it may, it was this immunity of the sands which gave the idea of submersion for the destruction of the phylloxera. It had formerly been remarked that long-continued rain was unfavourable to it, and that it shunned moisture by burying itself in the soil at great depths, only dying when the soil was thoroughly soaked. Eminent vine-growers, Faucon and P. Castelnau, concluded that submersion might be efficient, and since 1870 have submitted a part of their vines to this treatment. The results obtained were surprising. The following

table prepared by Faucon gives an idea of the improvement in the crop by the submersion of the vine :—

TABLE I.—*Showing the Effect of the Systematic Immersion of Vineyards on the Volume of Wine Produced.*

Year.	*Remarks.*	*Wine in hectolitres.*	*Wine in gallons.*
1867	Year before the phylloxera invasion	925	20,350
1868	First year of invasion vines fumigated, non-submerged	40	880
1869	Second year of invasion vines fumigated, non-submerged	35	770
1870	First year with submersion without manure	120	2,640
1871	Second ,, ,, ,,	450	9,900
1872	Third year with submersion and manure	849	18,678
1873	Fourth ,, ,, ,, (frost)	736	16,192
1874	Fifth ,, ,, ,,	1135	24,970
1875	Sixth ,, ,, ,,	2680	58,960

Henceforth submersion was not slow in finding numerous partisans. It has been practised a little all through France, and its use has extended to abroad. At the present time its efficacy is entirely accepted, and also the manner in which it is necessary to operate without injuring the submerged plants. In many districts the vines have been saved from complete destruction, and in other districts, formerly uncultivated, productive and flourishing vineyards have been created. Camargue is an example. In this district, where, however, the inundation water is charged with salt, submersion presents special difficulties, and good outfalls must be organized if it is wished to avoid seeing the salt appear at great distances.

Submersion in Actual Practice.—To submerge certain privileged vineyards the water of a neighbouring river may be deflected in part and brought on to the land by a natural slope. In countries where water is scarce it has to be propelled on to the land by powerful centrifugal pumps working day and night. In all cases of winter submersion the vineyard is divided into compartments of 4-6 hectares (10-15 acres), separated from each other by small dams and communicatory through small ditches. Before running on the water, care must be taken that the surface is well levelled so that the water spreads regularly. In very windy districts, such as Vaucluse and l'Aude, Barral advises the vineyard being divided into more numerous compartments, the divisions between which serve to break the waves raised by the wind before they attain too great an amplitude. Duponchel, an advocate of underground irrigation, advises, in executing the latter, to excavate around each stock so as to lay bare the roots of the tree, thus forming as many closed basins which communicate with each other by small channels. Water is made to flow therein and is imbibed to a great depth by the soil around the stocks. When the ground is sufficiently wet and all the water has been absorbed, all

that has to be done is to fill in the excavation with the dry soil placed on one side, to spread it and rake it. Submersion is performed either in winter or during the active period of the vegetation of the vine.

A. Winter Submersion.—Winter submersion is a process which cannot evidently be applied everywhere, and which requires special conditions, of which the following are the principal : (1) The ground must be slightly permeable, or very permeable but with an impermeable subsoil, such as is met with in the low plains of the French coast, and in isolated spots in the river alluvial soils of some of the chief water-courses. It is evident that too great a permeability of soil would require too large a volume of water. The daily decrease in the level of the water should not exceed a maximum of 10 centimetres (4 inches), a centimetre in depth corresponding to 100 cubic metres of water per hectare, say 1404 cubic feet per acre. (2) The ground ought to be perceptibly flat or very slightly inclined, a slope of 3 centimetres per metre (3 in 100) rendering submersion impracticable. (3) The vineyard should be situated, if possible, near to a stream of water, to an abundant spring, or to an artesian well, for it requires at least 6000 cubic metres of water per hectare, 84,780 cubic feet per acre. During the duration of the submersion, there is a daily loss of water, not only from absorption by the soil but also from evaporation into the atmosphere. The amount of water absorbed daily and the duration of the submersion have been studied by Chauzit and L. Tronchaud-Verdier, who have prepared the following table :—

TABLE II.—*Showing the Daily Loss of Water by Absorption by Various Soils during Submersion.*

Soil.	*Duration of Submersion.*		*Daily Loss of Water.*
	Autumn.	*Winter.*	
Slightly permeable . .	50-55 days	55-60 days	1 centimetre
Fairly ,, . .	55-60 ,,	60-65 ,,	1 to 4 centimetres
Permeable	65-70 ,,	70-75 ,,	4 to 7 ,,
Very permeable . . .	90 ,,	90 ,,	8 to 9 ,,

Evaporation into the atmosphere averages 6 millimetres in twenty-four hours in winter, though it reaches 10 millimetres in summer. (That is at the rate of an output of 1 litre per second per hectare, which is calculated in general as the general output of the channels serving to irrigate meadows.) (4) The duration and efficiency of the submersion, moreover, depends on the climate. It is known that in France it can only be practised in the centre and south. In the north the vines would have to pass the winter surrounded by ice, which would seriously injure them. The duration of the submersion should average sixty days in south and thirty days in central France.

B. Submersion During the Active Period of the Vine.—Where large quantities of water are deficient, summer irrigations, recom-

mended by Duponchel, Chauzit, and Dr. Debray, may be adopted. Debray has, in fact, remarked that the phylloxera is killed more easily during the active period of the vine, and that the duration of the submersion can be reduced to eight days in September, while fifteen to twenty days are required in October, and forty to sixty days in winter. In this connexion the underground irrigation described by Duponchel produces the best effect. So that submersion may be complete and efficacious, i.e. so that the water can penetrate 2 feet into the soil, it requires 1000-1200 cubic metres of water per hectare, say 250-300 litres (55-66 gallons) of water per stock. It is executed during dry periods, when vegetation is not very active. It has been found, on the other hand, that short, repeated irrigations lasting forty-eight hours in summer, especially if underground, are as injurious to the phylloxera as long winter irrigations. Whilst even three days' immersion in cold districts are injurious, underground irrigations of forty-eight hours in the dry regions of the South have a favourable action on the development of this plant. The causes, which in the exceptional conditions of the French climate insure the prosperity of the vine and the quality of French wines, are none other than the climate itself and the method of culture applied, the hoeing of the soil. It creates on the surface of the soil a shallow layer of friable earth, which by breaking the continuity of the capillaries arrests all evaporation from below. The rain-water thus imprisoned in the soil without communication with the exterior air constitutes that lasting store of underground moisture, which can only be evaporated by the plant which aspirates it by the roots and which loses it by the leaves. The sap thus elaborated acquires that peculiar property of being specially apt to develop fruits, whilst in moist districts submerged too often the more aqueous sap perfectly produces herbaceous vegetation and yields few grapes. To produce grapes of superior quality the fruits must be developed in a warm medium, and the roots be in a moist and warm medium. These essential conditions are awanting when prolonged superficial submersion is practised, but are not greatly affected by the underground irrigations recommended by Duponchel. Superficial sprinkling of the soil never gives useful results as regards grapes, but develops branches full of leaves (*pampres*). The superficial evaporation of the water so sprinkled by cooling the soil must retard the ripening of the crop. Submersions would therefore in general be rather prejudicial to the quality of the crop of a healthy vine. As a curative agent, they produce, on the other hand, two effects equally advantageous, they enable the vine to reconstitute its radicular apparatus (root hairs) more or less atrophied by the gnawing of this louse. From this point of view, the irrigation of the vines may be regarded as of practical utility, but it should be executed with the greatest of precaution so as to modify as little as possible the special conditions which insure the quality of the grape. A sufficient imbibition must be created to be injurious to the phylloxera, and favourable to the development of root filaments, avoiding all loss of heat by superficial evaporation. These conditions are realized by underground irrigation, especially if it be accompanied by

the addition of nitrogenous manures. In spite of the good results obtained by submersion and underground irrigation, these can only be regarded as a palliative and not as a curative method. Long winter submersions, short summer irrigations, do not kill all the phylloxeras which ravage the roots, and a new invasion always occurs; thus the treatment should be annual. To diminish the number of the insects and stimulate the vegetative energy of the plant is not a sufficient remedy, and to re-establish the health of the plant it is well to destroy the parasites by powerful insecticides, such as carbon disulphide and sulphocarbonates, at the same time as the radicular system of the vine is strengthened by subterranean irrigations. Simple submersion along with strong manuring, by stimulating growth by moisture and fertilizers perceptibly diminishes the action of the phylloxera; but it only creates, in reality, a *modus vivendi* between the parasite and the plant. In these conditions the latter may produce abundant growth of leaf, but it will only give in the majority of cases a mediocre grape. It follows from the interesting researches of Maquenne and Deherain, that when a soil is withdrawn from the action of oxygen, as happens when it is covered by a sheet of water, the nitrates which it contains disappear rapidly, owing to the action of certain reducing ferments. On the other hand, Muntz has tried to find out how the roots of vines immersed for two months can respire. This long privation of air ought to be injurious. To prove it, Deherain and Vesque submitted vines for fifteen days to immersion in distilled water, and found that they rapidly died, whilst others placed in aerated water were in perfect health. It is, therefore, the want of oxygen which in submersion may well prove fatal to vines, and that more readily when it is practised during the period of activity of the sap. River water used for submersion is the best, because it always contains air and nitrates, and vines submerged in these conditions resist for two months at least. That is an established fact which it is interesting to explain. The above-named scientific observers believe that the nitrates reduced by the ferments are converted into laughing gas which contains oxygen, and may support the respiration of the roots. This reduction observed in submerged land may become useful to vegetation, as it prevents the asphyxia of the vine. It is thus necessary to spread on the land an appreciable amount of nitrate if it be desired that the submersion should not injure the vine. French vine growers use in fact 600 kilogrammes of nitrate per hectare (528 lb. per acre), which is in no way exaggerated, but appreciably increases the cost of immersion. Certain muddy waters, such as those of the Dordogne and Garonne, for example, enable the amount of manure to be reduced a little. However, in spite of all the care brought to bear on immersion, there are vines which do not support the treatment. Espitalier cites the following species which die very rapidly: La Carignac, le Grenache, le Mourvedre, la Clairette, le Malbec, le Merlot, and in general all the valuable species, whilst the Cabernet, the Petit Bouschet, and l'Aramon accommodate themselves well to it. This explains why simple immersion has been replaced in large vine-growing countries like the Gironde by irrigations with

sulphocarbonate. Another drawback of submersion is that the vines planted in low grounds are attacked by all the cryptogamic parasites which multiply in moist districts and suffer more therefrom than anywhere else.

Moreover, the following, according to Tisserand, is the increase in the use of immersion and of insecticides in the treatment of the vine :—

TABLE III.—*Showing the Increase in Area of the Submersion and Insecticidal Treatment of Vines in France.*

Year.	*Submersion.*	*Carbon Disulphide.*	*Potassium Sulphocarbonate.*
	Hectares.	*Hectares.*	*Hectares.*[1]
1880	8,093	5,547	1472
1881	8,195	15,933	2809
1882	12,543	17,121	3033
1883	17,792	23,926	3097
1884	23,303	33,446	6286
1885	24,339	40,585	5227
1886	24,500	47,215	4459
1887			
1888	33,455	66,705	8089
1889	30,336	57,887	8841
1890	32,738	62,208	9377

To sum up, submersion, if of undeniable efficacy, is a barbarous process, with many drawbacks, which should be advantageously replaced by irrigations with sulphocarbonate or with carbon disulphide. Amongst the antiphylloxeric treatments we should advise, according to circumstances, the following choice: Annual submersion may be applied where exceptional conditions combine, accompanying it, however, by very abundant manuring. Irrigations with sulphocarbonate and carbon disulphide are reserved for *de luxe* vineyards, such as those of Bordelais, Burgundy, and Champagne. Carbon disulphide, applied by means of the *Pal injector*, to be adopted preferably in small and medium cultures, and especially where the want of water renders submersion too costly.

Spraying.—Spraying with cold water destroys the following parasites: *Capnodium* (*Fumagine* or smut of fruit trees).—Sorauer recommends playing a jet of cold water on the crown of the trees after pruning that part. However, this operation must be repeated every evening in summer. *Capnodium salicinum*, Mntgn. (hop black), may be prevented by spraying the leaves with cold water and repeating the process several days (Niajels). *Tingis Pyri*, Fb.—The pear tiger-beetle is fought against in the same way by spraying night and morning under the attacked leaves with cold water, or with a little soap

[1] A hectare is $2\frac{1}{2}$ acres approximately.—Tr.

added (Montillot). *Tetranychus telarius*, L. (red spider), which forms on different plants a disease called "la Grise," is very sensitive to moisture and does not stand repeated cold-water spraying long (Thomas). *Bryobia ribis* (gooseberry acarus) may be fought against by frequent sprinkling of the leaves. Spraying with water can thus be used as a preventive against different species of Fumagine or smut (*Capnodium*), as a means of killing acari, of which the Tetranychus (red spider) is the most widespread and injurious.

(b) Hot Water acts very energetically on insects and fungi, which die in contact with boiling water. Plants and their seeds generally stand heat better. That enables their parasites to be destroyed without injuring themselves.

Resistance of Insects to Heat.—All insects in seed are destroyed below 100° C. (212° F.). Bruchideæ (small weevils, pea-weevils) die in five minutes at 60° C. (140° F.). Ordinary weevils do not stand 50° C. (122° F.). Grubs touched by water of 50°-80° C. (122°-176° F.) die without exception. Coleoptera (beetles) which sometimes stand great heat never bear 100° C. (212° F.) (Schribaux, Bussard, and Etienne).

Resistance of Seed to Heat.—Seeds can undergo a dry heat without injury, whilst the action of moist heat, and of water above 60° C. (140° F.) is often injurious. Seed-corn, with the exception of maize, can support a heat of 100° C. for an hour without its germination being affected. In spite of the considerable loss in water which the grain undergoes in such conditions, seed-wheat, for example, which contained 13 per cent of water before being heated lost 9·4 of water during the operation. Their vitality is not diminished. Of Japhet seed-wheat heated for an hour in a stove at 105° C. (221° F.) 97 per cent still germinated; at 115° C. (239° F.) 95 per cent; at 116° C. (240·8° F.) 93 per cent; at 120° C. (248° F.) 56 per cent; at 125° C. (257° F.) 4 per cent. [Potatoes dipped in boiling water do not germinate.]

During researches on the *Alucite* Doyere likewise succeeded in heating seed-wheat dried *in vacuo* to 100° C. (212° F.) without it losing its faculty of germinating. By previously drying seeds at a low temperature Jodin heated grains of seed-wheat to high temperatures without alteration. Peas and garden-cress seed heated directly to 98° C. (96·4 F.) for ten hours were no longer capable of germination, whilst others submitted to the same heat for the same time stood the heat perfectly, after being heated for twenty-four hours to 60° C. (140° F.). The peas retained a germinating capacity of 60 per cent. Therefore, if seed be heated in such a way as to allow the water to evaporate previously, by heating in an open vessel or in presence of such substances as sulphuric acid, calcium chloride, and quicklime, they undergo no alteration. Seed-peas under such conditions stood heating for 206 days at 40° C. (104° F.).

Resistance of Fungi to Heat.—Fungi spores are generally remarkably sensitive to moist heat, but *per contra* they stand dry heat well. Schindler found that the spores of the *Ustilagineæ* which resist very great dry heats, are rapidly injured if the hot medium is saturated with water vapour. In these conditions the spores of black

rust perish at 60° C. (140° F.), those of brown rust at 45°-50° C. (113°-122° F.). Herzberg has compared the resistance of spores of different ages to the action of heat, and found the following temperatures as those at which they succumbed:—

TABLE IV.—*Showing the Temperatures at which the Spores of different Species of Ustilago are Killed.*

	U. Jensenii.	*U. Avenæ.*	*U. Perennans.*	*U. Hordei.*	*U. Tritici.*
	°C.	°C.	°C.	°C.	°C.[1]
Old spores .	47-50½	45½-47½	40½-42	43½-45	46-47½
Young spores	50-53	50½-53½	47½-50½	45½-47¾	45¼-47¾

It follows that the young spores are more resistant than the old ones, and that the temperature required to destroy the vitality of a spore is not the same for spores of different species.

Use.—The sensitiveness of parasites to hot water and the comparative resistance of plants have permitted the use of different treatments, especially preventive, to free plants from certain diseases.

Immersion or Steeping.—This consists in dipping seeds or plants in hot water to free them from disease germs adhering to their surface.

Hot Water Steeping of Seed-Corn to Kill Disease Spores.—Steeping seed-corn in hot water is practised before sowing to destroy the dormant spores of smut and bunt, which adhere to their surface and help to propagate these diseases. Brefeld, observing that cold water was injurious to the development of the spores of bunt, tried washing seed with cold water, and so obtained an appreciable but incomplete result. On the other hand, hot water has been recognized as deadly to the spores of these fungi, and treating the seed by hot water would wholly suppress cryptogamic diseases if the seed formed the sole factor of their propagation. To get satisfactory results steeping the seeds in hot water should be done in a strictly scientific manner. It is only efficacious if the temperature of the bath has been rigorously maintained at a certain degree. A greater heat than that required to kill the spores should be avoided, for it will appreciably diminish the germinative capacity of the seed, and may even destroy it. If there be a difference of sensitiveness between the seeds and the spores as regards heat, it is so small that a difference of a few degrees may be fatal. A low temperature should also be avoided, as it favours the disease instead of preventing it. Warm moisture helps, in fact, a premature development of the spores. The promycelium and the sporidia formed then attack the young plant as soon as hatched. It is a known fact that bunt as well as smut are more injurious to the plant the younger they attack it. When well done, steeping in hot water imparts to the seed in many cases a

[1] **To bring to Fahrenheit, multiply by 9, divide by 5, and add 32.**

greater germinative capacity, so that the plant has acquired a certain development when the spores which have escaped the treatment germinate. That is one reason in favour of steeping; the other methods of treating seed generally retard their germination. Steeping gave in certain cases results which it had been impossible to obtain by sulphating (Kuhn's), and it is in such particular cases that its use is prescribed, in spite of the difficulties of carrying it out which the farmer has to face in a peculiarly complicated plant, and the minute practical care required to secure a good result. B. Prevost was the first to observe that steeping seed-corn in hot water diminished the power of contagion of smut. In 1888 Jensen studied this treatment with great care and perseverance. The researches of Kuhn and Sorauer in Germany, J. Eriksson in Sweden, Linhart and Mezey in Hungary, Kellermann and Swingle in America, Prillieux and Schribaux in France, confirmed Jensen's very precise observations and conclusions. The following, according to Eriksson, is the manner in which Jensen's method should be applied on the large scale. The operation requires (1) A boiler or large pot in which to boil water. (2) Three tubs: No. 1 for hot water, No. 2 for tepid water, No. 3 for cold water. (3) Two willow baskets, completely lined inside, including the lid, with bolting cloth. (4) A thermometer. After having prepared a certain amount of boiling water, 50 litres (11 gallons) are withdrawn and run into the first tub, which is cooled to the desired temperature with 40-50 litres (9-11 gallons) of cold water. In the second tub about 20 litres (4·4 gallons) of boiling water are mixed with 80 litres (17·6 gallons) of cold water so as to get a temperature between 25° or 30° C. (57°-86° F.). Cold water is run into the third tub. The seed to be treated is placed in baskets, the lids of which are carefully closed so as to enable them to be completely immersed. Each basket contains about half a bushel of seed. After firmly attaching the basket to a stick it is plunged, first in the cold water to moisten the grain completely, then the same operation is repeated in the tepid water, taking care to raise up the basket and re-dip it several times. Finally it is dipped for five minutes in the hot water, raising and lowering the basket. The operation is finished, and the grains so treated can be immediately sown by hand, or they may well be spread out to dry. It goes without saying that it is necessary to disinfect the boards on which the grain is spread perfectly, as well as the bags to contain it, by hot water, bouillie bordelaise, or simply a solution of sulphate of iron. With three men and two baskets 400-500 litres (11-13$\frac{3}{4}$ bushels) of grain may be disinfected in an hour, at the expense of 25 centimes per hectolitre, or about 1d. a bushel. Kellermann and Swingle have simplified this process by dispensing with one of the three tubs, the cold water one. They only use a tub of water at 43°-54° C. (109·4°-129·2° F.) and a tub of water at 56° C. (132·8° F.). They use a basket of wire gauze of a capacity of 36 litres, say 8 gallons, which they only half fill with grain or simply a canvas bag. They first dip the basket for a minute in tepid water to warm the grain, then fifteen minutes in hot water at 56° C. They consider it useless alternately to raise and lower the basket into hot water. Each cereal is attacked by one or several species of rust, and it is necessary to

examine the action of Jensen's treatment on each of its parasites, *Ustilago Hordei*, Bref., on barley (Hordeum vulgare) and *Ustilago Jensenii*, Rost., on barley (Hordeum distichum). The steeping of grains of barley exhibits certain difficulties when these are still surrounded with glumes. By ordinary steeping, the spores between the grains and the glumes are not killed even if the water is raised to 60° C. (140° F.), whilst in an atmosphere containing the vapour of water, Jensen has observed destruction to be complete at 52½° C. (126½° F.). Eriksson got excellent results by softening them for four hours in cold water before steeping, and allowing them to swell for four hours in an aerated place, afterwards bagging them up. It suffices, therefore, to immerse the grain for five minutes at 52·5° C. (126½° F., Jensen), at which heat all the spores perish. The water can, without fear of diminishing the germinative capacity of the seed, be heated up to 60° C. (140° F.), barley standing that heat without injury. According to Kuhn, it is injurious to leave the grain for twelve hours in cold water before proceeding to the (hot) steep, but by not exceeding four hours. Sorauer found that such was in no way injurious to the development of the seeds. Kellermann, Swingle, and Kirchner dispense entirely with the first immersion in cold water, and claim to have obtained satisfactory results by one dip in hot water at 52·5° C. (126½° F.), even if the grains be glumed. Kirchner found that after a dip of five minutes in water of 56° C. (132·8° F.) grains of seed-barley germinated thus:—

TABLE V.—*Showing Effect of Steeping Seed-Barley in Hot Water on Germinative Capacity.*

	Germinated after two days. Per cent.	*Germinated after ten days. Per cent.*
Treated	74·5	98·0
Untreated	69·75	97·0

Besides the disinfectant action there is thus an evident increase in the germinative capacity of the seeds. Whilst the researches of Kellermann, Swingle, Jensen, Linhart and Mezey, Prillieux and Schribaux confirm this observation, Hollrung is of a contrary opinion.

Ustilago Tritici, Jensen (smut of wheat, *Triticum Sativum*); *Tilletia caries*, Tul., "stinking smut" or "bunt" of wheat; *Tilletia levis*, Kuhn (loose or flying smut of wheat).—According to Herzberg, the spores of *Ustilago Tritici* are destroyed at a temperature of 48° C. (118·4° F.), and those of *Tilletia* do not germinate after immersion in water of 55°-56° C. (131°-132·8° F.). By treating wheat grain by one immersion of five to fifteen minutes in water of 56° C. (132·8° F.), Sorauer obtained the following results:—

TABLE VI.—*Result of Steeping Seed-Wheat in Hot Water during different Periods of Time.*

Untreated grain	87 per cent of plants which gave 5·17 per cent of "bunted" ears.
Grain treated five minutes . . .	91 per cent of plants which gave 0·225 per cent of "bunted" ears.
,, ten minutes . . .	87⅗ per cent of plants which gave 0·157 per cent of "bunted" ears.
,, fifteen minutes . .	87⅗ per cent of plants which gave 0·071 per cent of "bunted" ears.

By treating the grain with 0·5 per cent of blue vitriol he obtained 86⅓ per cent of plants. It may therefore be inferred that an immersion of five minutes suffices, and that it has an advantage over blue vitriol because it stimulates germination instead of retarding it like the latter. Klebahn, however, is of opinion that immersion has no advantage over vitriol steeping, and Kirchner asserts that it diminishes the germinative power. Selby found that the same result was got by immersion as by treatment for twenty-four hours with a solution of 0·5 per cent of blue vitriol, 0·2 per cent of formaline, and 0·75 per cent of potassium sulphide. When wheat is immersed on the large scale against bunt it is well to dip the grain first in water, skim it, and cast aside all those grains which float. These are precisely the bunt-infested ones. Those which lie on the bottom of the water are alone dipped in the hot water.

Ustilago Avenae, Rost. (loose smut of oats, *Avena sativa*) ; *Ustilago perennans*, Rost. (smut of oats, *Avena elatior*).—The spores of *Ustilago Avenae* stand air heated to 52° C. (125·6° F.), but they do not stand dipping in hot water at 54°-56° C. (129·2°-132·8° F.) (Sorauer). Kirchner found that seed-oats treated in that way gave the following result against untreated :—

TABLE VII.—*Showing Effect of Steeping Seed-Oats in Hot Water on Germinative Capacity.*

	Germinated in two days.	*Germinated in ten days.*
	Per cent.	*Per cent.*
Treated	24·75	84·5
Untreated	6·75	81·75

Treatment on the large scale lowers the percentage of diseased plants to about 0·2-0·7 per cent (Eriksson). According to Kellermann and Swingle, a fifteen minutes' dip in water at 55·6° C. does not alter the germinative power of oats, and all authors agree in saying that the immersion of seed-oats is better than treatment with blue vitriol, because it stimulates instead of retards the germination. It is therefore from this point of view a useful discovery, and Klebahn is of opinion that this treatment, general for all other cereals, is prescribed for oats.

Urocystes occulta, Rabenh. (smut of the stems of rye).—By immersing seed-rye for five minutes in hot water Kirchner obtained against untreated grain the following results :—

TABLE VIII.—*Showing Effect of Steeping Seed-Rye in Hot Water on Germinative Capacity.*

	Germinated in two days.	*Germinated in ten days.*
	Per cent.	*Per cent.*
Treated	91	95·5
Untreated	95·25	98·0

Trials on a large scale by Klebahn did not give better results. The immersion of seed-rye presents no advantage in this case over treatment with blue vitriol, because it retards germination like the latter.

Ustilago Panici-Miliacei, Wint. (smut of millet).—Treatment with

blue vitriol or immersion may be employed indifferently, as they both give the same result. The millet seeds must be left seven and a half to twelve minutes in water at 55° C. (131° F.).

Ustilago Maydis, Corda (smut of maize).—Nijpels prescribes the immersion of maize by Jensen's method ; it gives good results.

Ustilago bromivora, Fisch. (smut of brome grass, *Bromus arvensis*).—According to Rostrup immersion has also been tried with success against this disease.

Sphaerella Tulasnei, Junez (black of cereals, *Cladosporium herbarium*). — Giltay prevented the development of this disease by immersion in hot water. Kolpin Kavn prevented it entirely on barley and oats by Jensen's immersion at 52°-53° C. (125·6°-127·4° F.) for five minutes, after previously softening the grain for fifteen minutes in cold water.

Puccinia (rust of cereals).—The numerous experiments of Galloway in America to diminish the rust of cereals by dipping the seed for fifteen minutes into water heated to 56° C. (132·8° F.) have not given the result anticipated. The treated seed gave as many diseased plants as the untreated. That is due to the method of development of the fungus, which does not appear, in fact, to propagate itself through the seed. Immersion has also been used to prevent beet diseases, due to fungi propagated through the seed. These diseases are *Pythium de Baryanum*, Hesse; *Rhizoctonia violacea*, Tul. (beet Rhizoctone) ; *Phoma tabifica*, Pril. et Del. (disease of the petioles of the leaves) ; *Pleospora putrefaciens*, Frank. (rottenness of the heart). Jensen's method has given excellent results, and it follows from the trials made by Hollrung that immersion, instead of injuring the seed, on the contrary stimulates their germination. Treatment with cold water greatly increases the germinative capacity of beet seed ; but it must not be kept ninety days after immersion before sowing, because the effect gradually disappears. If the seed be sown soon after immersion an excellent result is obtained with very few diseased plants. The procedure is as follows : The seed, in a wire-gauze basket, is immersed for six hours in cold water, left to drain ten to twelve hours in an airy place, then dipped for five minutes into water heated to 53·5° C. (128·3° F.), taking care to dip and raise the basket at regular intervals. Nothing further is required but to pass the seed into a bath of cold water, and it may be sown at once, or after standing for not more than ninety days. Summing up, Jensen's method sometimes gives results inferior to treatment by blue vitriol, because it scarcely ever diminishes the germinative capacity of the seed treated ; it is only really prescribed for the disinfection of seed-oats, for the results are undoubtedly superior. For all other cereals blue vitriol, bouillie bordelaise, or potassium sulphide may be prescribed. The latter process was recommended by Jensen himself in 1895 ("Ceres" powder) as capable of replacing immersion.

Immersion of Seed against Insects.—*Phylloxera.*—Balbiani's researches on resistance of phylloxera eggs show that non-rooted buds can be treated preventively by one dip of five to ten minutes in water heated to 45°-50° C. Experiments renewed in 1887 by G. Couanon, G. Henne-

guy, and E. Salomon confirm the results obtained. This method is currently used to-day. Not only does it cause no prejudice to slips catching root, but it seems, on the contrary, to facilitate it. And the importance of this treatment is so much the greater as it follows from determinations made in Algeria (1885), in Champagne (1890), and in Lorraine (1894), that new phylloxera hot-beds have no other origin than plants coming from countries infested with this formidable insect. G. Couanon and J. Michon resumed the same experiments and extended them to rooted plants which are most frequently used in the reconstitution of vineyards. Rooted Noah plants, dipped for three, four, and five minutes in water at 53° C. (127·4° F.) (51° C. at the exit, 123·8° F.), were planted at the same time as test samples. They took root completely, as well in the greenhouse as in the open air, and the vines grew very finely. Dipping in water at 53° C. (127·4° F.) is thus a practical and economic method for disinfecting vines, rooted or not, for it kills at the same time both the insects and their eggs. It has also the advantage over the sulphocarbonate treatment recommended by Mouillefert, that it does not require, like this latter, two to three hours, and has no injurious action on the plants (Balbiani). Disinfection by hot water gives very satisfactory results; the same process has been used for other fruit trees intended for sale, and cochineals, the woolly aphis, and other injurious insects, have been simultaneously destroyed. According to Danesi, all fruit trees, the peach excepted, stand very well being dipped for five to ten minutes into water at 53° C. (127·4° F.). To ensure complete disinfection the whole plants must be entirely dipped into the water at 53° C. (127·4° F.), and dried in the air on a copper grating. They can then be packed in disinfected moss and despatched.

Bruchus Pisi, L. (pea-weevil).—To kill this insect Fletcher recommends the following method: A vessel is taken which is half-filled with the infested peas, and boiling water poured on until they are entirely submerged. The vessel is then filled with cold water, and left to stand for twenty-four hours. The peas which do not suffer from the treatment and which are entirely freed from the insects they sheltered can then be sown. De la Bonnefon advises to drop the peas into water and leave them there for some hours. The peas which remain at the bottom are put into an oven the temperature of which is 60° C. (140° F.). After some time they are taken out and then sown.

Hot Water Spraying.—Spraying plants with hot water has not only been used to destroy injurious insects, but also to cause certain fungi to disappear, such as the *Erysipheæ* or mildews, which crawl on the surface of the epidermis without ever penetrating into the interior of the tissues. It is owing to this peculiarity that they can be destroyed by hot water. The leaves of plants stand without injury sprayings of 77°-85° C. (170·6°-185° F.), whilst at that temperature the mildews disappear entirely. The roots alone of the plant must be protected, because they suffer from contact with water at that temperature. Hot spraying has been used against the following mildews: *Uncinula Americana*, How. (oidium of the vine); *Sphaerotheca pannosa*, Lev.

(mildew of the rose bush); *Sphaerotheca Castagnei*, Lev. (mildew of the hop).

Hot water has found numerous applications against insects very sensitive to heat. *Galeruca* of the elm; *Formica*, ants; *Pierides* of the cabbage; *Cochylis Pyralis* of the vine; Cabbage lice; *Diaspines*, Cochineals, red spider.

Galeruca Calmariensis (*Galeruca* of the elm).—To destroy this insect, Robert sprays the stock and the lower part of the trees with boiling water. The time for doing so is selected when the larvæ are being transformed into grubs around the stock, i.e. about the end of July or beginning of August.

Formica (ants).—Boiling water destroys ants. It may be used each time that there is no risk of touching the roots, which do not stand hot water at that temperature.

Pieris (*Pierides* of the cabbage).—When they are not destroyed when they are small, the grubs of *Pierides* (white butterflies) so ravage cabbage as to render them unsaleable. Riley has observed that the grubs die when they are sprayed with water at 55° C. (131° F.), whilst cabbage leaves do not suffer at that temperature.

Conchylis Ambignella, Hubn (*Cochylis* of vine); *Tortryx vitana* (*Pyralis* of vine).—Scalding is the best method of destroying these insects. It consists in spraying the stocks with boiling water when vegetation is arrested, and when the insects have chosen the fissures in the bark as a common refuge. This process, discovered in 1828 by Benoit-Raclet, vine grower at Romaneche (Saône et Loire), was not known until 1838. Raclet experimented on the same vines for ten years, and after having found all the advantages of scalding, he advised its use, preferably in March or April. According to the researches published in 1868 by Terrel des Chênes, it has been definitely decided: (1) That scalding, even when applied ten years running, did no harm. (2) That it not only destroys *Pyralis*, but also many other insects of the vine. (3) That it also destroys the vegetable parasites of the vine, mosses, lichens, etc. (4) That it stops the growth of adventitious buds along the old wood which is a loss of sap for the stock and thus saves pruning. However, in spite of the excellent results, this method is practised very little, and that because it requires a litre of boiling water per stock, and it is not easy to use such large quantities in the middle of a field. For some years scalding of vines has become common by an improvement in the apparatus. The water is now heated in a portable boiler (fig. 1) fitted with two lugs by which it can easily be carried. It costs 30-50 francs (24s.-40s.). When the water boils the workman is warned by a whistle on the safety valve. He then fills a sort of tinned-iron coffee-pot (fig. 2), holding a litre, and covered with cloth, or better still with a double jacket, so as to prevent cooling. The water must be at 80° C. (176° F.) at the time it touches the stock for the destruction of *Pyralis*, and 90°-100° C. (194°-212° F.) for *Cochylis*, so that it may penetrate the silky cocoons which protect the small grubs. To increase the temperature of the water carbonate of soda may be added; 5° or 6° C. (9°-10·8° F.) extra are thus obtained which makes up for the exterior cooling. In emptying the coffee-pot entirely on each stock the workman must

act rapidly. He should with the drawn-out spout of the coffee-pot pour the hot water on the stock, rising in a spiral from the bottom, so that the water at the required temperature penetrates into all the interstices of the bark. The operation must be performed from below upwards, for if scalding was begun from the top of the stock the excess of water, perforce cooled, would flow over the lower parts and fill the interstices; the boiling water poured afterwards would have no mortal effect on the insects on the bottom of the stock, because they would not receive it directly. This precaution is particularly necessary in treating old vines, because these are generally the refuge preferred by grubs owing to the rugosity of the stock. Two workmen suffice to carry out the scalding; one feeds the fire and fills the boiler as the boiling water is drawn off, the other runs the hot water into the coffee-pots and pours their contents on the stocks. Working thus, 1500-2000 stocks can be treated per day. The boiler

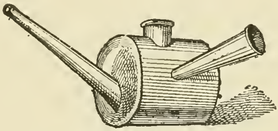

Fig. 2.—Coffee-Pot for Scalding Vines with Hot Water.

Fig. 1.—Portable Boiler.

consumes about 200 kilogrammes (4 cwt.) of coal per day. To diminish the labour, large boilers are also used, with taps to which india-rubber tubing is attached ending in a nozzle, with intermittent jet. This nozzle which projects the water on the stock has the advantage of penetrating deeply into the cracks of the bark. This process, though preferable to others, is only used in large vineyards. Scalding should be done after the vintage when the grubs have taken refuge in the bark, and before they have assumed the chrysalis form, for the latter is not so sensitive as the grub. It is carried out as soon as pruning is finished and preferably in calm, fine weather. To combat the *Cochylis* it is necessary to operate in October or November, whilst the grub has not yet finished its cocoon; against the *Pyralis*, which remains all winter as a grub, proceedings can be taken all winter up to May before escape from the cocoon. In districts where props are used these are boiled by placing them in cases, into which steam is injected for eight to ten minutes, or by steeping them in boiling water

for five minutes. Scalding carefully done with water at the temperature indicated is always efficacious, and has no injurious action on the vines if care be taken to perform it before the appearance of the bud. It is recognized that of all the treatments adopted against the *Pyralis*, scalding is still that which succeeds best. But it must be carried out with a certain regularity each year, otherwise the butterfly would again appear. This is the treatment which succeeds best against the *Cochylis*, provided it be done from October to November.

Margantia histrionica, Hahn (the red cabbage bug).—Murfeld has shown that these small bugs do not stand water heated to 65·5° C. (150° F.), a heat which does not alter cabbage leaves. Cochineals also suffer much from treatment with hot water. Reh found that generally they did not stand a great heat. Water at 54° C. (129·2° F.) kills them in forty minutes and water at 55° C. (131° F.) in twenty-two minutes; water at 60°-65° C. (140°-149° F.) kills the apple cochineal, *Aspidiotus ostreaformis*, and the pear cochineal, *Diaspis piricola*, but most cochineal stand a greater heat. The scalding of trees in winter is, therefore, an excellent method of freeing them from all these parasites.

Tetranychus telarius, L. (red spider).—In November this acarus takes refuge under the bark of the stock. The hot-water treatment can then be applied. The scalding executed as described above to destroy *Pyralis* can at the same time get rid of the red spider.

2. Hydrogen Peroxide, H_2O_2.—*Preparation.*—By decomposing barium peroxide by hydrochloric acid in the cold and then precipitating the baryta by sulphuric acid.

BaO_2	+	$2HCl$	=	$BaCl_2$	+	H_2O_2
Barium peroxide.		Hydrochloric acid.		Barium chloride.		Hydrogen peroxide.

Properties.—Hydrogen peroxide is a colourless syrupy liquid. A heat of 27°-30° C. (80·6°-86° F.) and light decompose it into water and oxygen. Aqueous solutions are very unstable but a small amount of sulphuric acid gives them stability.

Use.—The numerous applications of hydrogen peroxide in human medicine led to the expectation of good results in the treatment of plant diseases with this product. Hitchcock and Carleton tried hydrogen peroxide in solution of different strengths on the uredospores of *Puccinia*, but a solution of—

TABLE IX.—*Result of Treating Puccinia Uredospores with Hydrogen Peroxide of Various Strengths.*

0·1	per cent	acting during	7	hours	on spores of	*Puccinia graminis*, Pers.
1·0	„	„	„ 17	„	„	*Puccinia Rubigo vera*, Wint.
3·0	„	„	„ 14	„	„	*Puccinia coronata*, Corda.

far from destroying these spores rather favoured their development than otherwise.

CHAPTER II.

HYDROGEN SULPHIDE—SULPHUR.

3. **Hydrogen Sulphide (Sulphuretted Hydrogen, H_2S).—Preparation.**—By decomposing sulphides by a dilute acid. Iron sulphide is generally used. It is dropped in pieces into a Wolff's flask, two-thirds filled with water. By running in dilute sulphuric acid through a funnel there are produced (1) iron sulphate and (2) sulphuretted hydrogen, which is collected in a gasometer.

Properties.—Hydrogen sulphide is a colourless gas with the odour and taste of rotten eggs. It burns with a blue flame. It is very poisonous and treacherous, for it acts without any other warning than a bad smell. A small bird perished in an atmosphere which contained $\frac{1}{1500}$th; a horse does not live long in an atmosphere containing $\frac{1}{200}$th of this gas. Under its influence the globules of blood are unable to fix oxygen.

Action on Plants.—Hydrogen sulphide is also injurious to plants; in its presence the leaves are coloured with yellow spots, which entirely invade them, then the plants die. Schroder and Rems found that to be the case in the neighbourhood of factories which disengage a certain amount through their chimneys; gasworks amongst others, for coal gas always contains a certain quantity. An atmosphere only containing $\frac{1}{3000}$th of hydrogen sulphide, that is to say, an amount scarcely perceptible to the smell, but slightly blackening paper steeped in lead acetate, is poisonous to the plant. However, the toxic dose varies greatly with the species of plants. Even roots themselves are capable of absorbing it, and take a blue colour (Kny).

Action on Insects.—Mouillefert has examined the action of hydrogen sulphide on the phylloxera. On roots exposed in a flask filled with this gas these parasites died in three minutes, but whilst at the end of that time the adults were dead, the larvæ and the eggs did not appear to suffer. In an atmosphere containing 1 volume of H_2S in 150 volumes of air the phylloxeras were found dead after twenty-four hours. If it contained 1 volume of H_2S in 150 volumes of air it took forty-eight hours to destroy these lice completely. Now, as a litre of sulphuretted hydrogen weighs 1·5 gramme, an atmosphere containing 1 per cent of this gas by volume only contains by weight 0·0015 per cent of that acid. As that amount represents the limit of toxicity of this gas for the phylloxera, and as it requires 0·0016 gramme of carbon disulphide in 100 c.c. of air, it may be concluded that hydrogen sulphide is as poisonous to insects as carbon disulphide.

Use.—*Phylloxera.*—To utilize this property, therefore, of hydrogen sulphide, it only remains to discover a process capable of giving rise to the formation of this gas in the layers of soil round an infected vine. The alkaline sulphocarbonates fulfil this object. They decompose in the presence of moisture and the acidity of the soil into alkaline carbonate and hydrogen sulphide.

$$K_2CS_3 + H_2O + CO_2 = K_2CO_3 + CS_2 + H_2S$$

K_2CS_3	H_2O	CO_2	K_2CO_3	CS_2	H_2S
Potassium sulpho-carbonate.	Water.	Carbonic acid.	Potassium carbonate.	Carbon disul-phide.	Hydrogen sulphide.

Mouillefert tried ammonium sulphide, which acts perceptibly on the phylloxera in the same way as hydrogen sulphide. He buried around the roots, after having laid them bare, 500 grammes ($1\frac{1}{10}$ lb.) per stock of a mixture of 36 parts of calcium sulphide and 66 parts of sulphate of ammonia. Under the influence of moisture these two salts dissolve in the ground, and yield by double decomposition ammonium sulphide and calcium sulphate. The result was negative.

Melolontha vulgaris (cockchafer).—The insecticide property of hydrogen sulphide has been utilized to destroy numerous injurious insects, living in the soil, especially the *white worm.* Dr. Precht has taken out a German patent to claim a process of formation of this gas in the soil. Prior thereto Roy had recommended the burying in the ground of cinders rich in iron sulphide. In Italy good results are obtained against the white worm by ploughing in white mustard, more especially mixed with one ton of gypsum per acre. The decomposition of these plants would appear to produce much sulphuretted hydrogen.

Heterodera Schachtii, Schm.—The ploughing in of crucifers and gypsum did not give the result expected.

Cochineals—Coquillet did not succeed in destroying the cochineal of the lemon by covering this tree with an awning, and disengaging sulphuretted hydrogen under this improvised "cloche".[1]

4. Sulphur, S.—Sulphur, in combination with metals and metalloids, is very widely distributed in nature. It is chiefly met with as sulphides of iron, copper, lead, mercury, zinc, antimony, and arsenic. Native it is found in lacustrine deposits associated with marl, and especially in the precincts of volcanoes as a product derived from volcanic emanations. It is found in the mines of Vesuvius of Lateria, near Rome, in those of Etna and Stromboli.

Preparation.—When sulphur forms 50 per cent of the mass in which it is incorporated, it is fused in cast-iron pots at a heat not exceeding 140° C. (284° F.). The fused sulphur flows into horizontal retorts—exposed to the direct heat of a furnace—in which it is brought to the boil and the vapours conveyed into a large masonry chamber,

[1] *Note by Translator.*—But it must not be forgotten that sulphuretted hydrogen is heavier than atmospheric air in the proportion of 37 to 31, that is, 100 cubic inches of the former weigh 37 grains, and of the latter 31 grains. This difference in density must retard diffusion, so that the bottom of the plant would get an undue share and the top less than its share. Instead therefore of placing the generating vessel on the ground it should be at least well up the tree.

in which flowers of sulphur are first collected before the chamber becomes heated. The sulphur which follows comes in contact with the more hot sides, and when these have reached a temperature of 110° C. (236° F.) it condenses in the liquid state and runs into wooden moulds through an opening for the purpose. Brimstone is so obtained. For agricultural purposes sulphur is prepared under different forms: (1) *Sublimed sulphur*, or *Flowers* of sulphur, is an extremely fine powder of a yellow straw colour, which, examined under the microscope, appears as small rounded grains, studded with small points. It often contains sulphurous acid and sulphuric acid in the proportion of 1 per cent. (2) *Ground sulphur* is obtained by the pulverization, grinding, and sifting of brimstone. Ground sulphur can now be obtained, the fineness of which almost equals flowers of sulphur. It has the advantage of being neutral and cheaper. It consists of angular grains, and is paler than sublimed sulphur. (3) *Wind-blown sulphur* is of a bright colour, absolutely neutral, and can be passed through a 100 sieve, which proves that it is almost as fine as precipitated sulphur. It shows branching particles under the microscope and grains of regular dimensions. Like ground sulphur, it neither contains sulphurous nor sulphuric acid. It is dearer than ground sulphur. (4) *Precipitated sulphur* is impalpable. It is extracted from the spent material used for gas purification; when it is imperfectly purified it still contains tar, cyanides, and, as it is somewhat hygrometric, it burns the leaves. Hence its restricted use in the sulphuring of plants. It is obtained, also, by a chemical method: alkaline polysulphides, treated by hydrochloric acid in aqueous solution. give off hydrogen sulphide, and deposit at the same time a precipitate of almost white sulphur. This precipitated sulphur is dearer than the foregoing; it contains sulphuretted hydrogen and alkaline sulphides. (5) *Mixtures containing sulphur.*—In nature sulphur often occurs mixed with gypsum, carbonate of lime, sand, in proportions varying from 5 to 40 per cent. Such minerals are ground finely and marketed as Apt sulphur and Briabaux sulphur. The "Minerale Greggio" extracted in Sicily is an earth containing 40 per cent of sulphur, 2 per cent of alkaline carbonate, 11·8 per cent of carbonate of lime, 42 per cent of magnesia, 36 per cent of sulphate of lime, a little iron, clay, and arsenic. The value of these mixtures depend on their sulphur content; the gypsum and carbonate of lime have no anticryptogamic property. In many cases they are preferred, and that is what has contributed to the preparation of artificial mixtures containing 10-50 per cent of sulphur only. The Fonta powder, used since 1857, contains 10 per cent of sulphur and 90 per cent of talc. A marble worker of Saint-Beat, having tried a mixture of 50 per cent of ground marble, and 50 per cent of sulphur, found that this very efficient treatment occasioned no scorching on the vine, even during great heat. Neutral mixtures have, therefore, been prepared for this purpose, containing 50 per cent of sulphur and 50 per cent of gypsum, carbonate of lime, or clay. Now that cryptogamic diseases, like mildew and black rot, have invaded the vine already attacked by oidium, attempts have been made to reduce the multiplicity of treatments by mixing

sulphur with cupric powders. These powders, such as "Cupro-Calcite," will be dealt with when treating on oidium and mildew.

Use.—The use of sulphur goes back to 1846. It was by rule of thumb that the remedy was first discovered by the gardener Kyle, in experimenting in the greenhouses of Lyton with mixtures of sulphur and lime. At that time sulphur was already known as capable of curing mildew, and some gardeners used it. But when, in 1848, the oidium appeared, destroying the crops in the neighbourhood of Paris, J. B. Dumas, the Minister of Agriculture, ordered the disease known as *Oidium Tuckeri* to be examined, and the different remedies recommended to combat it to be tested. It was thus that Duchartre, Professor of Botany at the new Agronomical Institute of Versailles, aided by Hardy, the gardener of the palace, undertook the study of the action of sulphur, and that he decided it to be efficient against the oidium. Gouthier, horticulturist at Montrouge, constructed at this time a bellows for sulphuring, which contributed much to spread the use of sulphur around Paris. Henceforth, owing to this use of sulphur it was possible to contend against the oidium, and in 1852 and 1853 the vines of Chasselas and Thommery were entirely preserved. Sceptical vine-growers, persuaded that the oidium could only develop on perishing vines, sought at the same time a remedy by improving the culture. The good results obtained in 1852, 1853, and 1854, by Lafforgue, Rose, Charmaux, Rendu, and Mares, were disputed by Cazalis Allut, who, after six sulphurings, executed on 140 hectares (350 acres), did not suppress the oidium. There were long gropings in the dark, unsuccessful years, nevertheless, owing to the persevering efforts and profound study of Mares, a vine-grower of Herault, the action of sulphur on oidium was not long left in doubt. From 1857 sulphuring has spread more and more, and owing to this treatment oidium is no longer propagated to such an extent as to cause serious damage in vineyards. To contend against this disease France alone consumes 100,000 tons of sulphur.

How does Sulphur Act?—The different kinds of sulphur sold in commerce have not the same anticryptogamic value. In a general way that value is proportional to their pure sulphur content and to the fineness of division. Precipitated sulphur and blown sulphur are the products which attain the highest degree of fineness; sublimed sulphur and ground sulphur come very near them. In the manufacture of ground sulphur great progress has been realized of late years; formerly, in fact, it required 80 lb. to obtain a result analogous to that got from 40 lb. of sublimed sulphur, whilst now equal weights of these two products have the same anticryptogamic value, The adherence of the sulphur to the leaves depends on its fineness. From this point of view blown sulphur and precipitated sulphur are much superior to sublimed and ground sulphur, but the former are too dear. In extensive exploitations where they used sublimed sulphur almost exclusively, they have begun to replace the latter by ground sulphur, which has the advantage, like blown sulphur, of containing neither sulphuric acid nor sulphurous acid, and thus does not burn the leaves during great heat. To obviate the

drawbacks which sublimed sulphur has of grilling the leaves and irritating the eyes of the operators, it has been ground with inert bodies capable of neutralizing the acids which it contains. Neutral mixings, with a much more gentle action on the plant, and which act in the same way as the neutral sulphur above described, are thus obtained. It is thus that mixtures containing gypseous, bituminous, calcareous ingredients are met with, which have at the same time the advantage of favouring adherence in rainy weather. Many preparations are used in the south of France, and in Algeria, where they are specially applied for August treatment; but a larger amount must be used in inverse proportion to the sulphur content. It was interesting to know the action of sulphur on fungi living as parasites on plants, and several scientists devoted themselves to this study. It is recognized that the destruction of the parasite is more rapid the warmer the weather. With a temperature of 30°-40° C. (86°-104° F.) destruction occurs in one to three days; from 25° C. to 30° C. (77°-86° F.) it is already slower and takes four to five days; below 25° C. (77° F.) it is still more slow. According to Mach, Vesque, Sorauer, Hollrung and Dufour, this action of sulphur on the mycelium of fungi results from the formation of sulphurous acid, formed by the slow combustion of sulphur under the action of the sun and heat. Pollacci, on the other hand, believes that the sulphur is transformed into sulphuretted hydrogen, the vapours of which have a very energetic action on fungi. The third opinion is that of Mares and Mohr, who believe that the sulphur acts of itself, i.e. by its own vapour. The first hypothesis seems in fact inadmissible, for the simple reason that the sulphur cannot be transformed into sulphurous acid except at high temperatures and only by its combustion. But the sulphur does not act only on the mycelium of the fungi where it is in contact with it; sulphur placed at a distance acts equally well. Spread on the soil around the plant, it acts perfectly well if the temperature reaches 25°-30° C. (77°-86° F.). This observation was noted as regards greenhouses by Bergmann, Lord Rothschild's gardener in 1853, and by Viala, for vines in the open air. If it be therefore recognized that sulphur acts by the vapours which it emits, the nature of such vapours remains to be examined. Sulphurous acid must not be dreamt of; $\frac{1}{40000}$th of this acid in the air would burn the leaves. In warm and cold greenhouses where the plants are unceasingly exposed to the vapours of the sulphur emitted from the sulphur spread on the soil, these would not resist long if the ambient air contained sulphurous acid. The effects of this acid, to be examined further on, are disastrous to plants, and if it be admitted that sublimed sulphur burns plants, this drawback is only due to the presence of sulphurous and sulphuric acids. The formation of sulphuretted hydrogen is equally impossible. To determine of what the nature of the vapours emitted from sulphur when it is spread on the leaves and the soil and exposed to the action of the air and the sun may be at temperatures of 25°-40° C. (77°-104° F.), the author (Bourcart) made a series of laboratory experiments. Sulphur mixed with dry or moist soil with or without humus was placed in flasks with a tubulure. After having arranged these

flasks on a water-bath heated to 35°-50° C. (95°-122° F.), pure oxygen or a simple current of air was passed over these mixtures and the experiments kept up for eight days. At the exit from the flasks the gas passed through a series of bottles containing substances to retain sulphurous acid in some, hydric sulphide in others. Analyses made of the liquids collected and of the soil mixed with sulphur gave no trace of sulphurous acid, nor of hydrogen sulphide, hyposulphite, or sulphuric acid. Between 25° and 50° C. (77°-122° F.) therefore sulphur undergoes no chemical modification, and if it acts at this temperature on fungi it is by its own vapours. The odour of a greenhouse or a vineyard is in fact never that of sulphurous acid or hydric sulphide but that of sulphur. There is another reason in favour of the sulphuring of vines. Sulphur would appear in fact to have a direct action on vegetation which it renders more vigorous; it favours fecundation and otherwise stimulates the maturity of the grape which generally ripens eight days earlier. It is therefore advantageous to sulphur the vine even in the absence of cryptogamic parasites.

How should Sulphur be Applied?—Sulphur is generally used as a curative agent, and sometimes as a means of prevention. There is no absolute rule for applying sulphur, the essential point is to do it at the right time. The adhesion of sulphur can, in fact, be increased by applying it when the plants are still covered with dew, or after artificial moistening, but that is not indispensable, for dry sulphur generally adheres well enough on the leaves, and chiefly on the diseased parts. The mycelium of the *Erysipheæ* retained, in fact, lumps of sulphur, which persist longer on the spots attacked than on the healthy spots. If a persistent rain comes on or a storm in twenty-four hours after sulphuring, it is well to repeat the operation. Sulphuring may be done at any hour of the day. The dose of sulphur should suffice to cover entirely the diseased parts. During great heat it suffices to spread the sulphur on the ground at the foot of the plant. Sulphuring has been used preventively in greenhouses to prevent all cryptogamic diseases from appearing. The sulphur is spread on the soil, or on the heating pipes once a year. The plants thus live in a special atmosphere containing sulphur, which is opposed to the development of fungi, without injuring the plant. Different utensils have been used to spread the sulphur. The most simple is the *Sablier ordinaire*, a vessel of tinned iron, the bottom of which is perforated. It is filled with sulphur and shaken above the diseased plant. This instrument, however, much used in the south, has the drawback of spreading the sulphur very irregularly, and in too large quantity on the diseased plant. The *Sablier houppe* is constructed on the same style, but it contains meshes of wool which sift the sulphur and distribute it more regularly. But these primitive instruments have been almost everywhere replaced by bellows or blowers. The first was constructed in 1852 by Gonthier, and greatly helped to popularize sulphuring. This is the bellows still used in gardens. It consists of a box to contain the sulphur, which is fitted with a flat pipe at one of its extremities and an ordinary bellows at the other. For large vineyards there is a more practical instrument, which carries a larger

quantity of sulphur. It is a sort of *hood*, called a *soufreuse*, which the workman places on his back, and which can contain 10-12 kilogrammes (22-26·4 lb.) of sulphur. It is filled by an air-pump, with fan, which is wrought by a lever and a projector, the extremity of which, ending in a Raveneau jet, distributes the sulphur as a mist. The complete apparatus costs 28 francs (22s. 4·8d.). It can treat 1-2 hectares (2½-5 acres) a day. It must be perfectly cleaned after each operation, so that the sulphuric acid of the sulphur does not damage the metal part. The action of the sulphur on the *Erysipheæ* is unquestionable, the mycelium of which, crawling on the surface of the organs attacked, is quickly disorganized. All the mildews may therefore be effectively overcome, and it suffices for the purpose to sulphur at each approach of these parasites. But the use of sulphur does not stop there. In certain cases, in fact, where the mycelium cannot be destroyed, as the plant itself protects it, it destroys the external organs

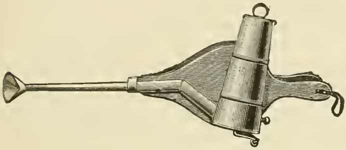

Fig. 3.—The Regulator Sulphur Bellows.

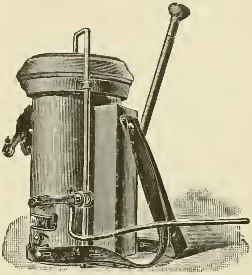

Fig. 4.—The Torpedo Sulphur Distributor.

of fructification, such as the *Conidiophoreæ*, and prevents the disease from assuming too great an extension by that alone. It is thus that sulphur acts on certain *Peronosporeæ* and *Black blights*. Diseases of a bacterian nature may sometimes be contended against preventively by the disinfection of the seed by sulphur. Sulphur also acts energetically on certain insects with a soft skin, and, according to Berlise, its action is rendered more efficient by steeping it in wood tar and then drying it. It has been found, however, to have no action on plant lice or cochineal.

Use against Bacteria.—Amongst the bacterian diseases of plants the following can be treated with sulphur :—

Rottenness or Moist Gangrene of the Potato ; Potato Scab ; Rottenness of the Sweet Potato (*Batates edulis*).—Nijpels and Stone recommend the use of sulphur preventively against these diseases. They advise that the potatoes intended to be planted be rolled in flowers of sulphur after being completely moistened so that the flowers of sulphur adhere more completely. They also recommend flowers of sulphur to be spread in the furrows in which the potatoes are planted.

Halsted estimates that manure with 170 kilogrammes of sulphur per hectare, say 150 lb. per acre, especially if it be accompanied with a manuring of 175 kilogrammes per hectare (154 lb. per acre) of kainit, gives results quite as satisfactory as the usual disinfection of the tubers by corrosive sublimate.

Nijpels, who controlled these experiments, found, however, that his own process gave a better result.

Use against Fungi.—Amongst the *Peronospora* we may quote *Cystopus candidus*, Lev. (white rust of the Cruciferæ); *Cystopus cubicus*, de By (white rust of the Compositæ). The sulphuring recommended by Weiss to combat white rust can have no effect, except preventively, at the time of lifting the seed. Then several sulphurings are applied, working preferably in the morning during the dew.

Uredineæ (rusts injurious to cereals).—Sulphur has no action on these diseases, the mycelium of which grows exclusively in the body of the nurse plant, and the spores of which are generally formed under the epidermis of the plant. The failure of Galloway, Hitchcock, Carleton, and Kellermann, was, therefore, to be foreseen. To disinfect the soil of these fields, as well as the wheat seed already sown, and prevent rust, Galloway tried burying sulphur in large quantities underground, but there was no improvement. These experiments, in fact, had no chance of succeeding, for it is known that the fungi of rust are heteroic, that is to say, they possess different methods of reproduction, which succeed each other during the course of the year on different plants in a determined order. Thus the barberry carries a form of fructification of the rust of wheat known under the name of *Aecidium*. The infection of the fields does not come from the seed but from the neighbourhood of certain special plants. Amongst the *Erysiphe* we may quote *Erysiphe communis*, Wallr. (mildew of the pea and bean). We can efficiently contend against this fungus, either by the use of sulphur or of sulphur and lime. Prillieux holds that sulphuring done as soon as the first spots appear may completely save the crop invaded. In the same category the most important of all the diseases, that which has caused the greatest ravages, is, without doubt, the disease known under the name of *Uncinula Americana*, How. (oidium of the vine). Since the decisive researches of Mares, vine-grower of Herault, it has been possible owing to the use of sulphur to contend victoriously against this plague without, however, causing it to disappear completely. It is quite as lively as when it first appeared, but by the rational application of sulphur its development can be circumscribed and its action on crops prevented. The disease always assumes new vigour when vine-growers are negligent in the execution of this treatment. But so that the latter may be absolutely efficient, it must be practised in special conditions. It is evidently difficult to fix in a precise manner for all regions the number of sulphurings to apply and the proper times, so as to protect the vine from invasion. Moisture and heat are, in fact, important factors of the development of the oidium; the question of climate, of exposure, of the year itself, have a great influence on the time of treatments and their number. There

are two methods of sulphuring vines: (1) *The repressive method*, which consists in sulphuring each time the disease appears on a certain part of the vine. That requires great attention on the part of the vine-grower, who should not let the disease extend too far. (2) *The preventive method*, which is most in use, consisting of three sulphurings at fixed intervals. The first sulphuring is applied when as yet no oidium has been observed at the time when the young branches reach 8-10 centimetres (3·2-4 inches) in length. The second at the time of flowering, and the third some days before *veraison*, taking care to sulphur the grapes chiefly. A supplementary sulphuring may be intercalated between the second and the third if special conditions are favourable to the reappearance of the disease at that moment. Dufour advises two treatments before flowering, the first, before the complete expansion of the leaves, the second a little before flowering. Spring sulphurings in no way injure the plant, and they may be executed at any hour of the day. But those which must be made in the hot season may injure the vines, the leaves of which are burned by the sulphur under the action of the sun. It is then necessary to comply with the following indications:—

(1) To use neutral sulphurs, chiefly mixtures, containing but little sulphur, instead of flowers of sulphur, always slightly acid, and because the former have a much more gentle action than pure sulphur. (2) To spread the sulphur preferably on the soil, instead of projecting it directly on the plant. This process is not only efficient, but without the drawbacks described above (Viala). When these few precautions are neglected, a large part of the crop is liable to be lost, owing to the corrosive action of the sulphur. The dose to apply at each sulphuring depends on the state of growth of the vine and the system of planting. For the first treatment it is well to use 15-20 kilogrammes (33-44 lb.) of flowers of sulphur per hectare (13·2-17·6 lb. per acre). At the time of flowering the dose is raised to 30 kilogrammes of flowers of sulphur (66 lb. per hectare, 26·4 lb. per acre) or 50 kilogrammes (110 lb. per hectare, 44 lb. per acre) of ordinary ground sulphur. Finally for the third operation it is necessary to spread 40 kilogrammes of sublimed sulphur (88 lb. per hectare, 35·2 lb. per acre) or 60-70 kilogrammes of ground sulphur per hectare (52·8-61·6 lb. per acre) and about 100 kilogrammes of Apt sulphur (220 lb. per hectare, 88 lb. per acre). When the ground sulphur is as fine as the sublimed, the quantity to use will be the same as for the latter. To preserve hothouse vines, it suffices to spread sulphur on the soil once a year; any invasion is prevented by this single treatment. Since other cryptogamic diseases—mildew, black rot, and others—have ravished the vine, attempts have been made to reduce the multiplicity of treatments, and cupric powders have been mixed with the sulphur, the isolated action of which is recognized as efficacious against these diseases. It has been advised to add 5 per cent of blue vitriol to the sulphur, or to incorporate sulphur in the cupric bouillies. There is even on the market a preparation known under the name of "cuprocalcite," which has in Germany the reputation of being at 25° more active than sulphur (Mohr). This product would appear to form a protective coat on the leaves, and by its adherence preserves

the plants longer against new invasions of oidium. But this opinion is not accepted, and it is generally believed that sulphur does not act in the presence of common salt. Pollacci and P. Viala condemn these mixtures, the first, because he believes that sulphur is not oxidized in the presence of copper salts, the second, because the experiments made at the Montpellier schools showed that these mixtures could neither prevent nor arrest the oidium and mildew. Mach and Mares agree upon that point, and this is the explanation : Copper salts have, in fact, the drawback of catching the vapours of sulphur, converting them into insoluble and inactive copper sulphide. If it be taken that sulphur acts by its vapours, it is evident that the action of the product is destroyed. These remarks are also of value in regulating the double treatment with sulphur and cupric bouillies. Since the introduction into viticultural practice of sulphating against mildew and black rot, the question of ascertaining whether sulphuring should be done before sulphating, or vice versa, has been often discussed. Laurent advises to precede the first sulphuring by the first sulphating, the second sulphating being done after flowering. But as the sulphur acts for four to five days, it is well to let this interval elapse between sulphuring and sulphating, so that these two treatments do not mutually destroy the effects of each other.

Drawbacks to Sulphuring.—Workmen engaged in sulphuring with sublimed sulphur sometimes have bad eyes, especially if they do not take the precaution to work with the back to the wind. To obviate this drawback, it is well to make them wear spectacles with cloth side-pieces, and to make them bathe the eyes several times a day with fresh water. Sulphur also gives sometimes a slight taste to the wine, owing to hydrogen sulphide, formed during fermentation. But this drawback is always caused by too dilatory sulphuring. If the wine still contains sugar, and is fermenting, it must be drawn off after fining in a cool cellar. If it does not contain sugar and already drawn off, it must be protected from any new production of hydrogen sulphide by the following treatment : In the case of wine with a feeble taste, one or two drawings off, during which the liquid is allowed to flow in a thin stream into a tank, may suffice to let the hydrogen sulphide escape into the air. L. Mathieu advises to run the wine in a stream over a plate of polished copper, so that it runs into a film : one part of the gas escapes into the air, the other is fixed by the copper. The copper plate must be cleaned from time to time with emery paper when it is blackened. If these methods do not suffice, sulphurous acid must be added to the wine as bisulphite of potash (metabisulphite of potash), about 10 grammes per hectolitre, say 7 grains per gallon. The two gases mutually destroy each other with the deposition of sulphur, which simple fining after a few days will completely carry down into the lees. By using for the last operation only 40 kilogrammes of sublimed sulphur per hectare (35·2 lb. per acre) or a stronger dose of Apt sulphur or any other product of low sulphur content, this drawback need not be feared.

Oidium Fragariæ, Harz (oidium of the strawberry).—Sulphuring

gives excellent results (Sorauer); *Phyllactinia suffulta*, Rebent. (mildew of the hazel and the ash-tree); *Microsphæra Grossulariæ*, Wallr. (mildew of the gooseberry leaf). Nijpels and Sirodot affirm the success of sulphuring.

Sphærotheca Castagnei (mildew of the hop).—Nijpels recommends to fight it, like the oidium of the vine, by three sulphurings, the first before flowering, the second during flowering, and the third when the cones are completely developed.

Sphærotheca pannosa, Lev. (mildew of the rose and the peach).—By methodical sulphuring, applied as soon as the disease appears, the rose bushes, most sensitive to this mildew, may be quickly cured. Vesque, Briosi, and Regel regard sulphur as the most sure and efficient method. The curative treatment of the peach miller (meunier du pecher) also consists in two or three sulphurings applied after ten days' interval.

Fumagine (smut of fruit trees).—Sulphur has the same action on capnodium as on mildews, but to be completely successful it is necessary to fight the lice and the cochineal, which are the first cause of the fumagine. Amongst the Sphæraceæ capable of being fought with sulphur there may be mentioned:—

Dematophora necatrix (white root rot of vine, etc.).—Narbonne has tried sulphur against vine rot. He advises to pull up the most badly attacked stocks; to lay bare the stocks not so badly attacked as deep as possible, and dust the roots abundantly with sulphur. It is useful to renew this operation several times before the stocks are covered up again.

Black Blights, the mycelium of which is in the interior of the plant, are more difficult to reach by sulphur, but as their organs of fructification, the conidiophores, are formed on the surface of the leaf, those organs can be got at by sulphur. The propagation of the disease is thus fettered. In this class are:—

Sphærella Fragariæ, Sacc. (spots of the leaf of the strawberry).—This very common and often harmless disease may, when it is intensely severe, stop the development, and entail the death of the plant. Nijpels recommends sulphur mixed with lime to prevent the disease on young plants.

Septoria Petroselini, Dmz. (var. Ap. Br. et Cav.), injurious to celery, is fought by sulphuring, like the *Cercospora Apii* (Duggar, Baily, and Sturgis).

Gloeosporium ampelophagum, Sacc. (grape rot).—This disease may be fought by sulphuring, but to succeed it must be applied in the beginning of the attack, so as to hinder the germination of the spores. To stimulate the action of the sulphur it is mixed with pulverized iron sulphate or lime. Paul Sol advises a very abundant first sulphuring before flowering, to distribute them plentifully in the same spots, and then to sow ferrous sulphate broadcast, 50 kilogrammes per hectare (44 lb. per acre). If the epidemic be not arrested it is necessary to renew this treatment. Viala obtained good results from mixture of sulphur and lime applied in the following proportions:—

TABLE X.—*Showing Proportions of Sulphur and Lime used in Mixtures against Anthracnose at Different Stages of Treatment.*

	First treatment.	*Second treatment.*	*Third treatment.*
Sulphur . . .	4 parts	3 parts	2 parts
Lime . . .	5 ,,	2 ,,	3 ,,

The first treatment is applied when the shoots are 8-10 centimetres (3·2-4 inches), the succeeding treatments every fifteen days. Briosi tells us that this sulphur and lime treatment is in actual use to fight anthracnose in the provinces of Pavia, Cuneo, and Messina. Solutions of sulphate of iron are reserved for winter treatment.

Cercospora Apii, Fr. (celery leaf blight).—Sturgis, Duggar, and Baily agree as to the efficacy of sulphur in fighting this disease when applied on a hot day, in which case sulphur is superior to all other chemical agents. Scribner dissents, and asserts that sulphur has little or no action. It is evident that sulphur cannot reach the fungus developed in the interior of the leaf, but in destroying the organs of fructification it may stop the propagation of the disease.

Cladosporium fulvum, Cooke (tomato leaf rust).—Mohr and Nijpels found that sulphur acts more effectively than copper salts to arrest this disease.

Clematite (*large flowered*), variety of *Clematis patens*, *lanuginosa et florida, disease of*.—This disease, to which many fine ornamental plants succumb, is attributed to the *Aecidium clematidis* or *Aecidium englerianum*, sometimes to *Nematodes*. The clematites disease cannot be circumvented by copper salts. But Fourrat found it possible to prevent it by laying bare the root, which he dusted with sulphur and afterwards covered with soil. The author's (Bourcart) experiments did not confirm this result.

Use of Sulphur against Insects.—*Crioceris Asparagi*, L.—Miss [1] Ormerod killed these insects by a spray consisting of 1 lb. of soap, 1 lb. of sublimed sulphur, and 1 lb. of soot, in 10 gallons of water.

Haltica nemorum, L. (earth flea).—These minute Coleoptera gnaw the leaves of young plants, and, owing to their numbers, cause great damage. Their destructive work may be stopped by dusting the plants, whilst still small, with a mixture consisting of 3 kilogrammes (6·6 lb.) of sublimed sulphur, 5 kilogrammes (11 lb.) of soot, and 50 litres (1¾ bushels) of quicklime per hectare (2½ acres). In the author's opinion the quicklime would have a preponderant action.

Haltica ampelophaga, Guer. (altise of the vine).—D'Aurelles de Paladines proposes to fight them with sublimed sulphur, or better, precipitated sulphur from gasworks. A more energetic method consists in using a mixture of black snuff, 12-15 kilogrammes, and Apt sulphur, 85-88 kilogrammes per hectare (10·4-13·2 lb. and 74·8-77·4 lb. per acre). A mixture of Apt sulphur and newly slaked lime may also be used.

Ephippigera Bitterensis (*Ephippiger of Beziers*), *Ephippigera Vitium* (vine ephippiger).—These grasshoppers devour the leaves, the

[1] Not M. (= Monsieur as in original).

young vine shoots, and the grapes. The crop is sometimes seriously compromised in the South of France by the great number of these Locustides. The grapes may be protected from their voracity by dusting the bunches in June, at the time when the Ephippigeres appear, with a mixture containing equal parts of sulphur and lime (Valette).

Eriocampa adumbrata (slug worm, or slimy caterpillar of pear-tree saw-fly).—Goethe recommends ground sulphur against the sticky larvæ of this saw-fly. This treatment is in common use in the Tyrol (Fischer).

Carpocapsa Pomonella, L. (codlin moth), the grub of which renders apples wormy. The sulphuring of apple trees, after flowering, is very efficient in drawing off the butterfly and preventing it laying its eggs on the young apples.

Phylloxera vastatrix (phylloxera of the vine).—Two processes have been used; that of Saintpierre, tried unsuccessfully, is quoted as a matter of history. It consisted in making a hole in the vine with a gimlet and in introducing 3 grammes of sulphur, then in re-closing the hole with a plug. The second process, that of Aman-Vigie, consisted in injecting into the soil, by means of a special bellows, a mixture of sulphur and sulphurous acid. But these vapours do not diffuse well in the soil and only penetrate it imperfectly. Henneguy, after trying this process, concluded that, applied in July and August, it exerted an unfavourable action on the propagation of this insect. If it be not capable of entirely freeing the vine from its parasite, it kills a sufficient number to allow the plant to live normally.

Use against Acari.—*Tetranychus telarius*, L. (red spider).—In hothouses it may be fought with sulphur. Maynard advises to heat the sulphur in a pot till it gives off fumes without inflaming. This operation should be renewed two or three times a week for several months. Sturgis asserts that this process destroys at the same time the *Peronospora*, De By, which resists repeated sulphurings in the open air.

Tetranychus bioculatus, W.M. (red spider of tea).—Playfair recommends to destroy it to spread on the tea before cutting 50 to 60 kilogrammes of sulphur per hectare (44-52·8 lb. per acre).

Eriophyes Vitis, Land., syn. *Phytoptus Vitis* (erinosis of the vine).—Erinosis may be arrested by repeated sulphuring, commencing sometime after the formation of the buds, when the branches are 8-10 centimetres (3·2-4 inches) in length. Couderc advises a hot day in spring for the operation.

Eriophyes Malinus, Nal., syn. *Erinium Malinum* (erinosis of apple and pear).—Sulphuring applied from bottom to top produces a satisfactory effect.

Eriophyes Piri, Pgst. C. (brown rust of the pear), syn. *Phytoptus Piri*.—Repeated sulphurings are efficacious if applied before the appearance of the disease.

Phyllocoptes Schlechtendali, Nal. (browning of leaves of pear and apple trees).—This fungus is readily accessible to insecticides, and sulphur acts in a sure manner.

CHAPTER III.

CARBON DISULPHIDE, CS_2.

5. Carbon Disulphide.—Preparation.—By projecting fragments of sulphur on to red-hot coals. On the large scale, vertical cast-iron cylinders built in masonry are used. They are filled with charcoal, which is kindled. As soon as it has reached a sufficient heat, the sulphur is introduced, gradually, through a side pipe. The sulphur melts, then vaporizes, and combines as vapour with the incandescent carbon. The gas escapes through a top pipe which communicates with two reservoirs, the first of which retains entrained sulphur, the second, which is cooled by a bath of cold water, condenses the vapours of carbon disulphide. The uncondensed gases, which are hydrocarbides, escape through a top pipe. Carbon disulphide flows into zinc reservoirs, where it is preserved under water. It may be rectified by drying it over fused calcium chloride and finally distilling it on a water-bath. For agricultural purposes, this rectification is useless; carbon disulphide in that case is led directly from the tank into the wrought-iron barrels, in which it is dispatched. The annual production of this product in France exceeds 2000 tons, almost the whole of which is used in agriculture.

Properties.—Carbon disulphide is a colourless liquid with a pleasant smell when it is pure, but almost always fetid on account of impurities which it contains. It is a very mobile liquid, which boils at 45° C. (123° F.), and consequently vaporizes with rapidity in an open vessel. Its vapours form with air mixtures capable, like coal gas, of detonating at the approach of a flame or an incandescent object. Owing to its ready inflammability the manipulation of carbon disulphide necessitates great precautions, and should be carried out far from any source of heat or flame, and wholly in the open air. Smoking is therefore forbidden in the sheds where it is handled, and when it is employed in the field the iron barrels containing this product should be deposited far from dwellings, and protected from the sun. To prevent the losses which would result from the evaporation from a cask being emptied, a good precaution is to run a small quantity of water into the cask. The water forms on the surface of the carbon disulphide a protecting layer, for the density of the water is lower than that of the sulphide. To ascertain the quantity of this liquid left in a barrel, a rod coated with tallow may be dipped into it. The rod will come back clean on all the part which touched the carbon disulphide, this product being a solvent for all fats. Carbon disulphide

is almost insoluble in water; the latter can dissolve at 1000th part of its weight. On the other hand, it is miscible, in all proportions, with absolute alcohol, and with a great number of organic bodies rich in carbon, such as fats, resins, camphors, vaselines. It exercises a very decided deleterious action on the animal economy; it produces headache and nausea, and after a certain time it may debilitate the nervous system. Its intoxications are not generally dangerous, for they cease by the simple removal of the cause. The workmen who handle this product are subject to its effects if precautions are not taken to protect them from the vapours. A dose of 120-150 grammes absorbed by the alimentary canal kills a dog. Carbon disulphide is used in medicine as an antiseptic against typhus, cholera, tuberculosis (Chiandi-Bey), against cancers (Whittaker), intestinal catarrh, and especially infectious diarrhœa (Dujardin Beaumetz), finally as an emmenagogue and anæsthetic. In the form of vapour it is used against helminthiasis and different diseases of the skin (Lewin).

Action of Carbon Disulphide on Plants.—Carbon disulphide is poisonous to plants. According to Sandsten it stops the movements of the protoplasm as soon as the plant comes in contact with even a very small dose of this agent. It is more injurious to the plant the more its application corresponds with a greater activity of the sap. The same doses used in winter without prejudicing the plants may become deadly in spring or in summer. Carbon disulphide is as injurious to the roots as to the part above ground. Plants should never therefore come in contact with pure carbon disulphide, nor into an atmosphere too highly charged with vapours of this insecticide. According to the experiments of Boiteau the roots may die if they are 4 inches from the spot where the carbon disulphide was injected into the soil. At the dose of 5 c.c. of carbon disulphide per 4 litres of soil, say at the rate of 5 oz. measures of carbon disulphide per 4000 oz. measures ($3\frac{1}{8}$ bushels) of soil, the vine would inevitably die; 2 c.c. of the same product injected into the same quantity of soil (4 litres) might be injurious to a potted plant. The moisture of the soil tones down to a certain extent the injurious action of carbon disulphide; its effect is so much the more injurious to the soil the more dry the soil and the higher the temperature. Just as much as contact with carbon disulphide and its vapours in strong doses are deadly to plants, so also to a like extent are weak doses indifferent to them when they are brought into contact with the roots either in 1 per cent solution in water. or in the form of vapour. The strong doses applied at the beginning of the phylloxeric invasion always entail the death of the vine, as well as that of its formidable parasite, whilst the cultural doses now used not only do not injure the vine but impart to it exceptional vigour. However, carbon disulphide produces even in a small dose, as Vincey has observed, an injurious action on the plant; but this action is only a passing one and hardly perceptible. In this way vines treated with small doses of carbon disulphide before the unhairing of the buds are thrown back seven to eight days beyond those not treated. Summer treatment always entails a passing slackening in the growth of the plant. Different plants vary in their

sensitiveness to this reagent, and it has been observed, for example, that trees generally support larger doses than annual plants. The aerial part of the plant also withstands carbon disulphide up to a certain limit, soapy emulsions and fumigations of carbon disulphide which, according to Morren, are not toxic up to $\frac{1}{1300}$. Goethe has observed that the vine can stand fumigations for twelve hours at 20° C. without suffering. Before the ascent of the sap the vapours of carbon disulphide may be prolonged without injury, and the dose in the same way. Targioni-Tozetti found that the dose of 2 per cent of carbon disulphide in soapy emulsion was the limit without injury to the leaves, whilst with petrol the dose was 2·5 per cent. A strong dose of carbon disulphide dries the leaves without altering the colour. Seeds likewise undergo the toxic effect of this insecticide, but according to Prillieux their power to withstand it varies with the species. Cereals, for example, lose 50 per cent of their germinative capacity after eight days of fumigation, whilst beet seeds undergo no alteration after three weeks of this same treatment. Coupin, who examined the action of this agent on grain compared with ether and chloroform, found that these two last bodies had no injurious action on wheat grain when the protoplasm is at rest, whilst carbon disulphide is always injurious thereto. However, if owing to moisture there is swelling and the protoplasm is active, ether also becomes injurious to the grain in the dose of 3·7 c.c. for 10 litres of air (3·7 in 10,000). According to Fantecchi's experiments seed corn dipped two minutes in carbon disulphide and afterwards dried in the air loses 10 per cent; dipped for one minute only in this insecticide then exposed afterwards for twenty-four hours in an atmosphere of carbon disulphide, it undergoes a loss of 50 per cent. The grain suffers the same loss if exposed for twenty-four hours in a closed vessel at 30° C. (86° F.); in an atmosphere containing 2 kilogrammes of carbon disulphide per cubic metre if the heat be raised to 40° C. (104° F.) the loss will be 100 per cent.

Action of Carbon Disulphide on Insects.—Carbon disulphide is one of the most efficacious of insecticides; it diffuses very rapidly in virtue of its great mobility and its very low boiling-point. Its anæsthetic and asphyxiant properties act very rapidly on the vitality of the insects which die paralysed in breathing it. Insects are generally more sensitive to the action of carbon disulphide than plants, so that by only using doses injurious to insects they can be overcome without hurting the plant. When an atmosphere saturated with the vapour of carbon disulphide can be created around the insects or their larvæ they die in a few seconds (Mouillefert). Phylloxera is so killed in thirty seconds. If the atmosphere only contains 0·5 per cent of carbon disulphide vapours (say 0·0016 of liquid sulphide) the action must last twenty-four hours to kill the phylloxera. An atmosphere containing 0·4 per cent of CS_2 vapour easily kills, in fifteen minutes, grubs, butterflies, grasshoppers, lice, and Coleoptera (balls). Injected into the soil to a depth of 4 inches doses of 40 grammes per square metre (say $1\frac{1}{3}$ oz. per square yard) for heavy ground and 30 grammes (say 1 oz. per square yard) for dry, light soil, suffices

to kill all the insects in that layer of earth. But solutions and emulsions of CS_2 do not act so rapidly nor so energetically as the vapour in a closed space. A 1 per cent solution does not kill the phylloxera until after twenty-four hours' immersion. Grubs strongly resist it. Those of the gypsy moth, *Ocneria dispar*, L., resist soapy emulsions containing up to 10 per cent CS_2. Burleso Dufour came to the same conclusions after trying to kill the cochylis (*Conchylis ambignella*, Hubn) by emulsions containing 3 per cent and 10 per cent of CS_2.

Action of CS_2 on Fungi.—This insecticide only acts on fungi in very strong doses, and is only used to kill root rot.

Influence of CS_2 on Fertility of Soil.—Carbon bisulphide, far from injuring the soil into which it is injected, as believed at the outset of its use in vineyards invaded by the phylloxera, exerts even in strong doses a favourable influence thereon. Aime Girard was the first to observe that carbon disulphide injected into the soil produced salutary effects on the soil treated, and greatly improved exhausted soils. In Alsace-Lorraine, where the antiphylloxeric treatment to extinction has so long been used, the marvellous action of carbon disulphide has been remarked by Oberlin. The latter, who has more especially studied the soil cure, has obtained surprising results. The culture of the vine being rigorously forbidden during the next ten years after the extinction treatment, the land was utilized for other crops. Now it was found that in all these soils all species of plants developed in a surprising manner, and that the rotations in use on non-disinfected ground were unnecessary on the former; CS_2 regenerates exhausted soils and allows continuous growing of the same crop. All papilionaceæ may be profitably cultivated on lucerne ground; for example, if the soil of the latter is previously tilled and disinfected, whilst in ordinary cropping one plant cannot usually be grown after another of the same nature without intermediate crops; CS_2 therefore renders rotations unnecessary, and enables the same plant to be cultivated for several years in succession. Oberlin, who has greatly helped to popularize carbon disulphide, got, like Girard, a double crop of trefoil after disinfecting the soil, and an appreciably increased yield with grain crops, beets, potatoes, and farm crops generally. In a tares (*Vicia villosa*) experimental field, treated with CS_2, Oberlin obtained, in 1893, 45 tons of green fodder per hectare (18 tons per acre), whilst in a non-disinfected field, used as a test, the yield was only 19 tons per hectare (7·6 tons per acre). He also experimented with haricots, and obtained by weight per are 85 kilogrammes in non-treated ground, and 125 kilogrammes in treated ground. Oberlin disinfects the soil as follows: Holes about 12 inches deep are excavated by an iron bar and 25 grammes of CS_2 run into each hole and the holes quickly closed; 10 kilogrammes of carbon disulphide must be buried per are. Three weeks after this treatment sow the seeds. Practical experiments on vines gave equally good results. Oberlin first, then Dufour, found that vineyards, before being replanted, have no need, as generally believed, of a rest, nor of any improvement by an intermediate crop after treatment with CS_2. The new vine can, in fact, be replanted as soon as the old stocks have

been extirpated if the following procedure be adopted : Trench the ground to 65 centimetres (2 feet 2 inches), then at a distance of 50 centimetres (20 inches) apart in every direction dig holes of 50-60 centimeters (20-24 inches) deep. Run into each 100 grammes (say 3½ oz.) say 40 kilogrammes (88 lb.) per acre, and close the holes quickly; the soil must remain in this condition until the spring, when the new plantation will be made. In vineyards reconstructed in that way the young vine stocks yielded in the third year 30 hectolitres (660 gallons) ; the fourth year, 110 hectolitres (2200 gallons); whilst the test vineyard non-treated only gave 74 hectolitres (1528 gallons). Here is, by a report of the Baden Botanical Station, a curious result obtained in onion-growing. Soils, completely exhausted by the culture of this plant, were appreciably improved by disinfection by carbon disulphide. Holes 40 centimetres deep, bored 50 by 50 centimetres (20 inches) in every direction, received 100-300 grammes of carbon disulphide, and the produce, which had fallen to 14 units per square metre, was raised to 22 by the dose of 400-800 grammes per square metre, and to 26 by a dose of 1000 grammes (2·2 lb.). These improvements, due to carbon disulphide, are very surprising, and efforts have been made to ascertain how this product acts on the soil, since it is void of any nutritive function, and how it can be the cause of intense yields in an exhausted soil.[1] There are a large number of parasites, both insects and fungi, which live in the soil at the expense of the plants, and looking at their grand opportunities for multiplying when the same plant is grown continuously for several years the exhaustion of the soil, it will be readily understood, is due solely to this accumulation of parasites which, attacking the plant by the roots, remove from it the means of nourishing itself. Carbon disulphide, injected into the soil, by destroying all these parasites, restores to the soil its primitive purity, and the plant, undisturbed by parasites, develops normally, and profits, by fertilizers, to give large crops. Carbon disulphide acts like the bare fallow, which also remedies soil exhaustion. By suppressing food from the parasites accumulated in the soil for a certain time the latter greatly disappear. Carbon disulphide is more effective than bare fallow, and gives complete and immediate results, because it enables the soil to be completely disinfected and to utilize it at once for a new crop. The infection of the soil is caused by fungi: *Dematophora necatrix*, Hartig ; *Armillaria Mellea*, Quelet ; *Roesleria hypogaea*, Thum. et Pass. ; by the *Anguillulides, Heterodera Schachtii*, Schm., and *H. Radicola*, Gr., and insects, the larvæ of which take several years to accomplish their evolution, such as the *Elaterides* (click beetles), cockchafers, etc. All these parasites multiply greatly, especially when they are omnivorous and not disturbed by rotations ; they are, in themselves alone, capable of preventing a plant from producing normal crops. Carbon disulphide in large doses creates in the soil a sufficiently poisonous atmosphere to kill them, and so sterilize the ground being cropped. Contrary to Foëx, Dufour, Oberlin, and Couanon, whose researches leave no doubt as to the action of carbon disulphideon the mycelium of different cryptogams,

[1] *Note by Translator.*—The onion is a sulphur-loving plant. The reason for increase in crop is obvious.

Perrault does not admit so great a destructive action on cryptogams. He holds that if CS_2 acted in that way on insects and cryptogams, it would also act on the useful micro-organisms, which live, in symbiosis, with a great number of our cultivated plants. There exist, in fact, in the soil microbes indispensable to the formation of nitrates, to the decomposition of organic matter ; and microscopic organs which, producing small nodosites on the roots, fulfil the function of conveying atmospheric nitrogen under an assimilable form (Wilfahrt, Nobbe, Hiltner, and Hellriegel). If Perrault's contention were well founded the fertilizing action of carbon disulphide would be illusory, because that state of things would have to be remedied by applying to the soil a strong dose of nitrogen, not as organic manure, but in the form of saltpetre. It has, however, recently been shown that carbon disulphide only temporarily affects the bacteria useful to agriculture, and Wollny formulates the results obtained up to now as to the action of carbon disulphide thus :—

(1) The introduction of carbon disulphide into arable land during the period of vegetation has the effect, according to the quantity applied, of either completely destroying vegetable life, or of causing temporary trouble. (2) When the sulphide is applied several months before cultivating the soil, the fertility of the soil is greatly enhanced. This action of the sulphide extends, according to the quantity used, over one or more periods of vegetation, and it is followed, if manure be not employed, by an important decrease in the yield of the field treated. The lower organisms which play an active rôle in the decomposition of organic matter and in the formation of nitrates in the soil, as well as the bacteria of the radicular nodosites of the leguminosæ, are not killed even by strong doses of carbon disulphide; their activity only receives a temporary check, to resume afterwards all its energy.

Use.—History.—Baron Thenard was the first who drew attention to the services which carbon disulphide might render in destroying the phylloxera of the vine, but his experiments, made in 1869, owing to the then defective methods of applying this insecticide, did not give the result expected. The method of application and the doses used play, in fact, a rôle of very great importance in the success of this treatment, and it was not until after the researches of Monestier, Lautaud, and Ortoman that carbon disulphide gave some good results. In 1873 these scientific observers concluded that carbon disulphide is not injurious, except in the liquid state, when it is brought into direct contact with the roots of plants; it is necessary therefore, so as to remedy this drawback, to inject the liquid at a certain distance from the plant in such a way that the vapours disengaged form around the roots an atmosphere sufficiently toxic to kill the parasites. With this end in view they recommended that the carbon disulphide be caused to act from below upwards by depositing this agent in holes pierced to a depth of 80 centimetres ($31\frac{1}{2}$ inches) ; although based on an excellent principle, the use of carbon disulphide too often caused the death of the vine, for the doses used, which varied from 150-375 grammes per stock, were too strong. Experiments by the Montpellier Agricultural Society, due to the initiative of the Viticultural Associa-

tion of Libourne, led to a gradual decrease in the dose, which was definitely regulated to 12-20 grammes only per square metre, say 24-28 grammes per stock. Dumas' researches showed that even 3 grammes per square metre ($\frac{1}{10}$ oz. per square yard) were sufficient to attain the object in view. Owing to the support of the Paris-Lyon-Mediterranee (? Railway), and the Minister of Agriculture, who established a superior Phylloxera Commission and Vigilance Committees in the districts invaded, carbon disulphide was employed on the large scale.

The efficacy of carbon disulphide in the struggle against the phylloxera was determined accurately, and the conditions under which it acted were determined by the learned researches of Crolas, Marion, and Jaussan. At the present time the utility of carbon disulphide is no longer in doubt; it has rendered, and renders, undoubted services, and its use has become universal. To give an idea thereof it will suffice to say that, in 1895, 60,000 hectares (150,000 acres) of vines were treated with carbon disulphide. This product is, moreover, destined to render the same services in agriculture and horticulture, and owing to its remarkable insecticide properties it may become, like manures, an indispensable auxiliary to farmers. It is already used against a great number of insects whose larvæ live underground at the expense of the roots, and the good results obtained have led to its use against the ravagers of the aerial part of the plant. There, however, its success has not been so great.

Its method of use varies according to the parasite to be destroyed. The best results are got when an atmosphere containing a dose poisonous to insects and their larvæ can be produced. This condition is easily realized underground, in granaries, hothouses, and under tents of impermeable cloth, with which small-sized trees may be covered. In these different cases liquid carbon disulphide is always used, and acts by evaporation. When an asphyxiating atmosphere has to be produced underground, the carbon disulphide is introduced to a certain depth by a pal-injector, which is regulated for the desired dose. In soils favourable to the diffusion of gases, such as those which are not too compact nor too moist, the vapours of carbon disulphide, in a dose of 20 grammes (307 grains) spread within a radius of 30-35 centimetres (10-12 inches) around the spot where it has been poured. These vapours remain long enough in the soil for the toxic atmosphere to produce its effect. According to the parasites to be got rid of the dose is diminished or increased, and injected to a variable depth. There are cases where the roots of the vine descend so deeply that the carbon disulphide must be injected to 80 centimetres ($31\frac{1}{2}$ inches), whilst to kill the larvæ living a few centimetres from the surface, one does not go down more than 20 centimetres (7·8 inches). To use carbon disulphide it is therefore necessary (1) To ascertain the exact spot where the parasites to be killed are, first making a trench and making it at about 20 centimetres (7·8 inches) below the invaded zone. (2) To choose the moment when the soil is in such condition as to allow the diffusion of carbon disulphide vapours into the interior of the mass, whilst at the same time it places the greatest possible obstacles in the

way of their loss. This moment varies with the nature of the soil to be treated. A clay soil, for instance, cannot realize favourable conditions when it is saturated with water, or when it is cracked by drought. On the contrary, a sandy soil, after a slight rain, is in favourable condition. The most propitious moment is when the soil presents a certain interior mobility and a great enough density on the surface. In these conditions the vapour of carbon disulphide easily diffuses around the roots, and remains imprisoned by the hard surface, which forms a sort of envelope. Those advantageous conditions may be realized artifically by injecting carbon disulphide into a very dry soil and watering the surface soil, after having carefully plugged the holes. (3) Never to stir the soil after treatment, for the carbon disulphide, already very volatile, would, in certain instances, escape into the air without producing its effect; it is therefore necessary, so as to employ it with success, to maintain it as long as possible in the infected zone. To attain this end recourse has been had to two preparations, which allow a less rapid evaporation of carbon disulphide.

Vaselinated Sulphide.—In 1874 Bouttin proposed a mixture of carbon disulphide and nut oil. Cubes of wood, imbibed with sulphide, and covered with silicate of soda have been tried but neither of these processes have given good results. Vaselinated sulphide was invented in 1887 by Dr. A. Meunier and examined by Cazeneuve: vaseline forms an emulsion with carbon disulphide and prevents it from evaporating rapidly. It was hoped, owing thereto, to lessen the chances of evaporation into the atmosphere and to prolong its action in the soil. Mixtures were tried of equal parts of the two substances, or of 30 per cent of vaseline and 70 per cent of carbon disulphide. In 1890, 250 metric tons of these substances were used in viticulture. It has been observed by Vermorel and Jossinet that the dose of 20 grammes of liquid carbon disulphide placed in each hole 35-40 centimetres round the vine suffices to kill the phylloxera, but when mixed with vaseline this quantity is not enough. However, if the holes be brought to within 10-15 centimetres of the stock, the conditions favourable to the action of this preparation are improved. Marion and Gastine conclude that there is no advantage in this mixture, since the dose of sulphide must be greater to give the same result. They further remark: If more than 50 per cent of vaseline be incorporated in the carbon disulphide, the evaporation which is produced during injection is as great as when employed pure, and finally the vaseline retains about 15 per cent of sulphide which it only cedes very slowly, and which remains without effect. Wooden cubes impregnated with sulphide as well as mixtures of carbon disulphide and heavy oils, tested by Marion and Gastine as far back as 1877, gave no advantageous results, and the pure sulphide should be preferred to all these preparations. It is a great error to imagine that carbon disulphide must develop slowly to produce a salutary effect. For the action of the sulphide to be effective, what is required, above all, is to create almost instantaneously an atmosphere highly charged with poisonous vapours around the radicular system invaded by the parasites and to maintain it there as long as possible. To slacken the evaporation of the carbon disulphide is to remove from

it one of its most precious properties, that of its great diffusibility. A slower evaporation will not create an atmosphere sufficiently toxic to kill the parasites. A great number of volatile substances, very poisonous to the phylloxera and used in the same conditions as carbon disulphide, have never been able to equal it, as their diffusion in the soil was too slow. To avoid the loss of carbon disulphide in the usual treatment with the pal-injector, the use of gelatinized capsules containing a dose has been tried. These capsules are arranged in holes made with a pal-injector, and afterwards plugged. Under the action of the moisture of the soil the gelatine finally dissolves, the sulphide flows out into the soil and rapidly evaporates, The operator has thus a convenient time without fearing loss of the sulphide to plug the holes and to water the surface of the soil to imprison the vapour after the rupture of the capsules. In spite of the apparent advantages of this process, it has had to be renounced in viticulture because the disengagement of sulphide was too irregular and not simultaneous in the zone treated. In horticulture these capsules are handy because they are easy to use and as they avoid the purchase of a pal-injector. (4) To distribute uniformly the sulphide in all the soil to be treated. This is done by placing the holes at equal distances from each other, and by using instruments which enable equal doses of this substance to penetrate into the soil. Carbon disulphide may be injected into the soil during almost the whole year. However, it is less injurious to the plant if the operation be performed during the time vegetation is at rest. In any case, its use should be avoided during the flowering period and when the fruit approaches maturity.

Instruments Necessary for applying Carbon Disulphide.—The pal-injector already mentioned must be placed in the first rank of instruments intended for this purpose. It is a sort of compression pump, intended to convey a known dose of carbon disulphide to a certain depth. The *pal-Gastine*, which may serve as a type, consists of a reservoir, in zinc or copper, intended to contain carbon disulphide. This instrument possesses, in its interior, the body of a pump in which a piston moves. Under the pressure of the latter a valve opens and closes the opening of a long channelled tube, which penetrates into the earth. An aperture near the sharp end lets the sulphide escape. Two handles and a pedal serve as a point of support to the workman. The output can be regulated at will. In hard and gravelly soils the workman is preceded by an assistant, who pierces the holes with an iron crowbar called *Avant-pal*, the tube of the *pal-Gastine* not being sufficiently solid for this purpose. To avoid this drawback, Vermorel has improved this pal and has invented the *pal-Excelsior*, which differs from the foregoing by the fact that the valve is placed in a lateral tube by which it is possible to have a much stronger perforating tube. To regulate the quantity of carbon disulphide it suffices to give a longer or shorter course to the piston, by intercalating washers in the body of the pump. By this means the *pal-Excelsior* can be regulated at will for an output of 5, 6, 7, 8, 9, and 10 grammes of carbon disulphide at each injection. In actual sulphurization the pal is seized by the two handles, then sunk in the ground by the help of

the pedal. By pressing on the rod of the piston the carbon disulphide is projected into the soil, then the rod re-ascends of its own accord, under the action of an inside spring. The pal is withdrawn from the soil, and an assistant rapidly fills up the hole with a wooden rod ending in a rounded piece of iron or lead. To hasten the operation, which ought to be done very rapidly, it is well to employ three workmen, and to possess two pals. A workman fills the container of the pal by a tap fixed on the barrel, whilst the second injects, and the third plugs the holes. In vineyards arranged for the work the pal is replaced by sulphide wagons or traction injectors, which do the work much more rapidly, and thus economize manual labour. The mechanism of these machines comprises a roll, acting like a pump, which after drawing the carbon disulphide into a reservoir, spreads it into a hollow traced by the sock of a plough, which immediately covers the hollow which has just been excavated. Amongst the different systems of instruments the most common are those of Gastine of Marseilles, Vernette and Saturnin of Beziers, and Cobal of Toulouse.

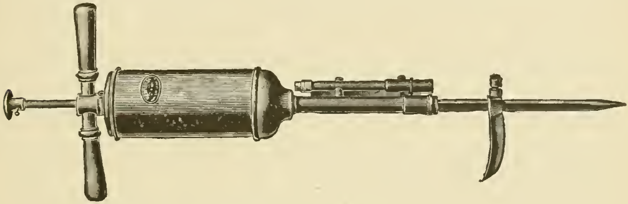

Fig. 5.—Pal-Excelsior.

In other appliances the organs of distribution of the carbon disulphide are fixed to some sort of plough. Such are the *Salvator vitis* of Audebert of Bordeaux and the *Sulfureur libournais* of Defontaine of Izou. These machines are blamed for not depositing the sulphide deep enough in the soil. To secure a good distribution of the carbon disulphide through the layer to be disinfected, recourse is often had to 1 per cent aqueous solutions. At that strength the carbon disulphide is not injurious to the plant, but perfectly capable of killing subterrannean parasites.

Disinfection in Closed Spaces.—It is used in granaries where food-stuffs are stored. It suffices in that case to spread on the floor a certain dose of carbon disulphide, after having closed all the vents in the place. A toxic atmosphere must contain 0·5 per cent of carbon disulphide. When it is required to disinfect a small quantity of corn, it suffices to enclose the grain in a cask containing 0·5 per cent of sulphide, and to keep the cask hermetically closed for twenty-four hours. The grain sometimes retains a bitter taste after this treatment, but this is removed by stirring the grain with a shovel, or by passing it through the fanners. What is important to be pointed out is, that the grain suffers no alteration and retains its germinative and alimentary faculty. Carbon disulphide therefore presents real advantages

over sulphurous acid employed in like conditions, the latter having the drawback, according to Balland, of removing from the gluten the special qualities which enable it to be used in bread-making.

Destruction of Aerial Parasites.—When the plant attacked is of no great height it is covered with a tent of impermeable oil-cloth, or by a zinc bell, or better still, by half a barrel (petroleum), as is done in the treatment of vines by sulphurous acid. By this means an atmosphere containing vapours of carbon disulphide can be created around the tree, capable of rapidly destroying the parasites without injuring the plant, whilst, according to Ritter and Moritz, the phylloxera under its *gallicole* form and its winter egg, is killed in half an hour at a temperature of 20°-30° C. (68°-86° F.) in an atmosphere containing a sufficient dose of sulphide. The vine supports without suffering the action of this gas for twelve hours at 20° C. (68° F.). It is, however, to be observed that the longer the duration of the treatment, and the higher the temperature, the greater is the action of the sulphide on the plant. The dose of sulphide to use ought never to be greater than 0·5 to 1 per cent. For this purpose 50-100 grammes of sulphide per cubic metre are placed in a cloche or in a flask hooked to a branch, or on the soil in a saucer. In hothouses the atmosphere must not contain more than 0·5 per cent of carbon disulphide. To destroy the larvæ of xylophages, such as the larvæ of the Saperdes, the grubs of Cossus, and of Sesia, a poisonous atmosphere is formed in the burrows they make in the trunks of trees. To imprison the vapours it is necessary to close the burrows with some sort of mastic. This treatment is in no way prejudicial to the plant. Where fumigation in an enclosed space is impracticable, recourse is had to pulverizations with soapy emulsions, made in the same way as those with a petroleum basis, and containing 2 per cent of sulphide, the limit of innocuity on the tender parts of the plant. In certain cases the invaded spots are plastered with the pure sulphide by means of the brush, and that chiefly when it is a case of the destruction of the woolly aphis (*Schizoneura lanigera*). The action of the sulphide employed in this way is not so perfect as in a hothouse, or under a cloche, its rapid evaporation not allowing of a sufficiently long action which thus often allows the parasite to escape death.

Use against Cryptogamic Diseases.—*Dematophora necatrix*, Hartig.—Jean Dufour, Director of the Station Viticole de Lausanne, succeeded in arresting *Rhizoctinia* of the vine by applying carbon disulphide at the rate of 200 grammes per square metre (say about 7 oz. per 40 inches square), after having removed the diseased roots. According to this eminent observer carbon disulphide not only acts by destroying the mycelium of the fungus in a great measure, but it also imparts greater vitality to the vine. The latter, rendered more vigorous, resists afterwards the action of the fungus which may have escaped the destructive treatment. Oberlin and Foëx believed that the improvement in soils got by the use of the exterminating treatment against phylloxera is due chiefly to the destruction of the mycelium of injurious fungi which intervening crops are not capable of eliminating, because they can live if need be just as well as

saprophytes as parasites on different plants. To disinfect a vineyard it is advisable to proceed as follows: After having staked out the ground by metric divisions, two holes per metre 25-30 centimetres (10-12 inches) in depth are made with a pal and 100 grammes ($3\frac{1}{2}$ oz.) of carbon disulphide are injected into each. In compact soils four holes are made, each of which receives 50 grammes of sulphide. It is always well to water the ground after this operation, so as to maintain the carbon disulphide as long as possible in the soil. This treatment is generally carried out in winter, and the vines are replanted the following spring. Carbon disulphide is not applied against any other cryptogamic diseases, but it possesses, however, a certain action on the spores of fungi. Dr. Delacroix in his researches on the *Fusarium Dianthi* (P. et D.) observed that the conidia are killed after seven hours in an atmosphere saturated with carbon disulphide, and that the chlamydospores are destroyed after twelve hours. The spores of fungi resist the action of carbon disulphide much better than insects, but it is not impossible that the sulphide will yet find some applications for the destruction of certain fungi refractory to the action of the different cryptogamic bouillies.

Use against Anguillulideæ (Eelworms).—*Heterodera Schachtii* (nematoide of beetroot).—Kuhn, who has principally studied this parasite, believes that the exhaustion of the soil in beet cultivation is not due, as is generally imagined, to the want of potash or other elements necessary to intensive cultivation, but exclusively to the exaggerated development of this eel. Rotations are powerless to destroy this parasite, because it lives quite as well on other plants. Willots' experiments with gas liquor only gave incomplete results. Carbon disulphide, tried in the year 1875, was not recommended until 1877 by Aimé Girard, after he had discovered its surprising effects. In Germany, Hollrung also got good results by the use of this insecticide, but provided it was used in a large dose, that is to say, of 1·8 metric tons per hectare (say 1584 lb. per acre) spread in the holes placed regularly 50 centimetres (20 inches) apart.

Heterodera radicicola, Greff. (root eelworm).—Dussuc recommends for the destruction of this eelworm the cultural treatment used against the phylloxera. The different nematoides that live on the roots of all these plants of large scale agriculture, and which neither deep cultivation nor rotations can destroy, contribute in great measure to create that peculiar state of soil known as *exhaustion*. In these conditions when their presence in very great number is recognized in a soil, it is well to have recourse to a complete disinfection of the soil, using massive doses of carbon disulphide. This treatment will maintain the fields in good condition for several years, especially if care be taken not to convey thereon farmyard manure liable to contain eelworms.

Use against Insects.—Insects, the larvæ of which live at the expense of the roots, may be destroyed by carbon disulphide used in the conditions indicated to destroy the phylloxera.

Melolontha vulgaris (cockchafer).—In carbon disulphide an infallible remedy has been found for the destruction of the larvæ of

the cockchafer, the white worm, on condition that it be applied at the right time and intelligently. It is even more active than benzine, recommended under similar circumstances by Vermorel. Falconnet and Treyre, who were the first to use this insecticide as far back as 1883, pointed out the absolute efficiency of this treatment. There does not exist for this particular application of carbon disulphide precise data as to the depth to which the injection should be made. The white worm travels, in fact, constantly in the soil; it rises and descends according to the hygrometric condition of the soil, and the temperature. In winter it buries itself at a depth where it cannot be reached by insecticides, in summer it ascends, on the contrary, into the superficial layers where disinfection cannot reach it, the tension of the vapour of carbon disulphide not being sufficient, and the larvæ often finding enough air to escape asphyxia. It is therefore necessary to seize the moment when the larvæ are about 30-40 centimetres (12-16 inches) from the surface of the soil, that is to say, about the month of October or November, when it descends, or in the month of February, when it re-ascends into the surface layer to commence its ravages. So that the treatment may be followed by a complete result, it is necessary that carbon disulphide invade the whole zone of soil occupied by this dangerous larva; the treatment ought, therefore, to be preceded by trenching with the spade which should determine for the moment the spot occupied by the white worm. The injection is regulated in such a way that carbon disulphide is volatilized appreciably in that zone, which will be reached by working 5 centimetres further down. It is useless to treat the soil during the period of the year the perfect insects appear, and which current language designs as beetle seasons, the laying being done in the month of June, the white worms, which are hatched a short time afterwards, do not yet cause appreciable damage, and moreover these young larvæ reside so near the surface soil that it would be difficult to attack them. The treatment is put off generally until the month of February of the second year, and the time chosen the moment the larvæ appear on the surface of the soil. The laying of the beetle, occurring only once in three years, there is only one favourable period occurring in this interval. It only lasts a few months. As the treatment costs 120 francs per hectare, say nearly £2 per acre, the annual expense will only run to 40 francs per hectare, say 13s. per acre. It can therefore be applied in market garden or in nurseries without entailing great expense. It has the advantage of killing at the same time rats, mice, moles, mole crickets, grey worms, and all the parasites which injure our crops. Falconnet and Treyre have found that the dose of 10 grammes per square metre (154 grains per 40 inches square) is sufficient in orchards to kill the larvæ in the deep layers of the soil. Vermorel and Couanon recommend on the contrary a stronger dose, that is to say, 20-28 grammes per square metre ($\frac{3}{4}$ to 1 oz. per 40 inches square). To spread this insecticide use is made of a pal-injector, which is regulated to distribute 5 grammes (77 grains) at a time in holes placed 50 centimetres (20 inches) apart in every direction. But the number of holes and the dose varies according to the nature of the soil and the kind

of crop. On nurseries planted with grafts, the maximum dose is 200 kilogrammes, say 4 cwt. per hectare (176 lb. per acre) ; in these the pal ought to be sunk 35 centimetres (say 14 inches) in the soil, so as to inject the carbon disulphide lower than the roots, and thus to avoid contact with the liquid sulphide. On a soil free from any crop the best moment to treat it is likewise in the middle of the month of February, and in general it may be said that injections ought always to be made fifteen days before planting, provided the soil is very dry. If carbon disulphide has to be employed in the months of May and June, whilst the white worm exercises its ravages in the upper layer of the soil, Vaucher advises to spread a dose of 50 grammes per square metre, in six to eight holes of 18-20 centimetres (7-8 inches) deep. Gelatine capsules containing 2½ grammes of sulphide render good service under these conditions. It is necessary carefully to avoid working the soil fifteen days at least both before and after the treatment.

Eumolpus Vitis, F. (Ecrivain).—Besides the very efficacious method which consists in shaking the branches above a special funnel, carbon disulphide, applied as in the case of the phylloxera, is capable of giving good results. It is applied at the rate of 200 kilogrammes per hectare. This treatment has succeeded perfectly in Hungary (Dr. Howart and Sajo). Its use in France has been recommended by Dussuc and Debray, in Germany by Taschenberg.

Vesperus Xatarti.—Olivier recommends to destroy these insects by treatment with carbon disulphide, applied in the months of December and January. For that purpose, two or three holes are made 25 centimetres (10 inches) from each stock, and into each hole 7 grammes (¼ oz.) of carbon disulphide is poured.

Enchlora Vitis (green vine beetle).—Marchal recommends carbon disulphide as very efficacious in destroying the larva of this beetle.

Pentodon punctatus (Pentodon ponctué).—Dussuc advises to destroy the larva of this Coleoptera by carbon disulphide, and previously to disinfect soils intended to receive grafted plants where this insect is very abundant.

Lethrus cephalotus, Fb. (big-headed lethrus).—Carbon disulphide, it appears, gives good results in the destruction of this Coleoptera ; however, it is advisable to make weak injections, for these must be done very near the stock, the insect being always found hidden in the neighbourhood of the roots.

Oryctes nasicornis, L. (rhinoceros).—Carbon disulphide gets rid of them.

Melolontha Fullo (fuller beetle) ; *Rhizotrogus solstitialis* (St. John beetle).—To destroy these insects in infested regions the sulphide should be applied before planting.

Larvæ of the Elaterides (wire worm).—A great number may be destroyed in infested fields by laying down small pieces of apple as bait, which as soon as invaded are collected. But complete destruction is only possible with carbon disulphide, which, in the different tests made, has always given good results. Targioni Tozetti has used the sulphide with a dose of 300-400 kilogrammes per hectare (264-352 lb. per acre), or even at a dose of 100 kilogrammes per hectare (88 lb.

per acre) in emulsion with 100 kilogrammes of 4 per cent caustic potash and 15 kilogrammes (13·2 lb. per acre) fish oil. The result is not perfect, except after having renewed the treatment, the success of the first injections only being momentary.

Brocchi, as well as Mohr, have obtained excellent results against *Agriotes sputator* by using capsules containing carbon disulphide. The larvæ of the *Elaterides* are very hardy, and as they live mostly in the upper layers it is advisable to make holes 20 centimetres (7·8 inches deep) and run in a dose of 50 grammes of sulphide per metre, say 775 grains per 140 inches square. It would be advisable to roll the ground before treatment to consolidate it and prevent the sulphide from evaporating too rapidly. Amongst the weevils there are several which can be destroyed by carbon disulphide.

Peritelus griseus ; Othiorhynchus sulcatus, Fb. (black vine weevil).—Muller advises to make three or four holes per square metre round the tree and to distribute therein by the pal-injector a total dose of 25 grammes of carbon disulphide. Insects hidden underground should be exterminated at the end of May, and the larvæ during summer.

Othiorhynchus ligustici, L. (Liveche's weevil).—Girard, Vergnete, Lamothe, and Brocchi have shown that treatment with carbon disulphide is most efficacious. *O. raucus*, Fb., and *O. picipes*, Fb. (clay-coloured weevil), both injurious to fruit trees and vines, may be treated in the same way.

Bruchus Pisi, L. (pea-beetle).—This weevil passes its entire evolution on the pea. Peas intended for sowing should be disinfected. Reh has observed that the treatment by carbon disulphide was in this case as efficacious as hot water. It suffices to treat peas for twenty-four hours in a closed vessel and to aerate them afterwards. This same process is applied to *Bruchus rufimans*, Schonh. (haricot-weevil) ; to *Bruchus granarius*, Payk (bean-beetle) ; *Calandra granaria*, L. (calender or wheat-weevil) ; *Calandra Oryzæ*, L. (rice calender), and *Anobium paniceum* (maize-weevil). The larvæ of these weevils live inside the grain and cause great ravages in granaries. The following processes have been used to exterminate them. Spread on the floor of the infected granary 1 litre of carbon disulphide (35·2 fl. oz.), pile the grain in a heap on the drenched space, and cover it with a tent or a cloth. The grain may also be spread in a closed chamber, in a layer 20-30 centimetres deep and 1-2 litres of sulphide per ton of grain to be disinfected uniformly distributed thereon. The whole is covered with sacks, and the sulphide allowed to act for twenty-four to thirty-six hours. This method of disinfection has the drawback of being attended by certain fire risks, and that is why it is done far from dwellings. In that case a cask is used, which is filled with grain, then the carbon disulphide is run in at the rate of 500 grammes (1·1 lb.) per 100 kilogrammes (220 lb. of wheat). The cask must be closed, with its lid, so as to roll it, first, shortly after closing and then a second time, twelve to twenty-four hours afterwards. Nothing remains to be done but to empty the grain, which is perfectly disinfected (Pabst and Hollrung). The bad taste imparted to the grain does not last long, and it rapidly disappears if shovelled a few times, or if passed through the fanners.

Hypera polygoni.—The larvæ of this weevil attaches itself to the stem of the poppy and forms a disease of that plant. Sorauer advises the application to the stems of a soap emulsion, containing a little carbon disulphide.

Saperda Carcharias, L. (large poplar longicorn).—It is recommended to inject carbon disulphide into the burrows occupied by the larvæ and to stop the holes at the base of the trunk with mastic. The larvæ of *Lucanus cervus* (Cerf volant) in old oaks are destroyed in the same way, as well as numerous capricorns, of which the following are the principal :—

Cerambyx heros, F. (great capricorn injurious to oaks) ; *Cerambyx dilatatus*, Ratzeb. (maple capricorn) ; *Galeruca calmariensis* (elm galeruca).—The larvæ pass through their first stage of metamorphosis underground, in the neighbourhood of the trees, in the end of July, and the perfect insects pass the winter in the same spot. It is therefore at these two periods that it is possible to destroy them by injecting into the soil 50 grammes of carbon disulphide per square metre, spread all round the stock, in eight holes only 20 centimetres (7·8 inches) deep. Watering of the soil before the application facilitates the action of the sulphide on these insects lodged in the upper part of the soil. Carbon disulphide has also been employed with equal success against :—

Gryllotalpa vulgaris (Courtiliere, Taupe, Grillon), (mole-cricket, churr-worm, eve churr, or earth crab).—Soils are rendered immune for ten years by carbon disulphide on condition, however, that there is co-operation between the different proprietors of the neighbouring cultivated fields. The total expense per hectare rises to 180-200 francs for ten years, say 20 francs (16s.) per hectare per annum (say 6s. 4·8d. per acre), which is trifling. The sulphide is employed at the rate of 40 grammes per square metre if the soil is compact, and at the rate of 30 grammes only when the soil is light. The latter type of soil is always preferred by the insect. In Italy, near Nola, where mole-crickets have caused serious ravages for twenty years, carbon disulphide has been used over a great area, and has been recognized as an infallible insecticide. Janin advises gardeners to use capsules containing 3 grammes of sulphide, and to deposit them here and there in their burrows, and afterwards to water the soil. It is preferable to make injections in the burrows, by making numerous holes, in the spring.

Tipula oleracea (daddy longlegs), *Tipula pratensis* (the spotted garden gnat).—Marechal got good results by injecting carbon disulphide. To free a lawn from the larvæ of these insects 20 grammes of carbon disulphide should be spread in three holes per square metre, the grass trenched after a few days and sown with the seed. There may be destroyed in the same way the *Tipula crocata* and the *Tipula melanocera*, injurious to young plantations of *Abies balsamea* and of *Pinus sylvestris*.

Spilographa cerasi, F. (cherry spilograph, cherry fly).—Besides the process which consists in collecting all the wormy cherries, Taschenberg recommends as an excellent means of destruction, to bore

numerous holes, in the month of July, of 10 centimetres (4 inches) in depth, around the cherry trees and to run in a little carbon disulphide, to stop them afterwards, and water the soil. The soil under the tree may also be watered with a solution containing 1 part in 1000 of carbon disulphide.

Vespa vulgaris (common wasp), *Vespa crabo.*—To destroy these hymenoptera 20 grammes, say $\frac{3}{4}$ oz. by weight, of carbon disulphide is run into their nest during the night, and the orifice plugged.

Agrotis segetum, W. V. (common dart moth).—The grub of this moth is known as the grey worm. Coste-Floret has observed that the French vine, which regularly undergoes antiphylloxeric treatment, does not suffer from grey worm, whilst American vines, which are not treated with carbon disulphide, suffer much. The grubs of the following insects may also be combated by carbon disulphide, using the same process :—

Agrotis exclamationis (hart and dart moth), *Agrotis Tritici*, *Agrotis Ravida*, W. V., *Agrotis nigricans*, L., and *Agrotis corticea*, all injurious to crops. *Agrotis vestigialis*, Hfu., injurious to pines and larches. *Hespialis Humuli*, L. (the otter moth), the larvæ of which gnaws the large roots of the hop from the month of August to the month of April.

Cossus ligniperda, L. (goat moth).—Taschenberg recommends to make injections of carbon disulphide in the burrows as soon as the grub appears, and to close the orifices with mastic; the grub is asphyxiated without injuring the tree. Trees attacked interiorly by the grub of the following butterflies may be treated similarly :—

Zeuzera Æsculi (leopard moth of chestnut), *Sesia apiformis*, L., Hornet (wood leopard moth).

Amongst the *Microlepidoptera* which may be combated by carbon disulphide, those injurious to stored grain may be quoted, such as :—

Sitotraga Cereallela, A. (grain alucite); *Tinea granella* (grain mite); *Asopia farinalis* (flour mite).—They are destroyed like the wheat weevil.

Cemiostoma Scitella, Zell.—Sirodot recommends to combat this grub and exterminate the butterfly to hook on to the tree a flask containing carbon disulphide. All the Lepidoptera, of which the larvæ are minute, may be destroyed in the same way, such as *Elachista*, *Nepticula*, *Incurvaria*, *Coleophora*, *Cosmopterix*, *Gracilaria*, etc.

Plant Lice.—According to a report of the Minister of Agriculture of the United States, published in 1895, all root lice, of which the phylloxera is the best known, may be destroyed by carbon disulphide injected into the soil, around the infected plant. Amongst these lice, which live on roots, the following are the most important: *Phylloxera*, Fonsc.; *Schizoneura*, Hart.; *Pemphigus*, Hart.; *Tychea*, Koch.; *Trama*, Heyd.; *Rhizobius*, Burm. These lice, which, for the most part, do not live exclusively on the roots, become especially injurious because they wither the latter up by their perpetual suction, and so kill the tree.

Phylloxera vastatrix (phylloxera of the vine).—To destroy the phylloxera, either aerial or underground disinfection is used. The aerial disinfection of the winter egg of the phylloxera, under the form

of "gallicole," is done by methods described further on. However, it may be carried out by means of carbon disulphide on grafts and buds from a contaminated region, because a sojourn of an hour in an atmosphere saturated with the vapour of this insecticide is sufficient to kill the phylloxera and its eggs. Buds and plants may be so disinfected.

Underground Disinfection.—This method of disinfection is the most important. It is, in fact, because it withers the roots of the vine that the phylloxera kills this plant and destroys entire vineyards. Amongst the numerous insecticides, proposed for the destruction of the phylloxera, carbon disulphide, and its derivatives, the sulphocarbonates, have alone given good results. According to the district, and also as circumstances may require, two distinct treatments may be applied:—

1. The extermination process, destroying all the insects of the vine and the plant itself.

2. The cropping process, only destroying a portion of the insects, and not injuring the vine, so that the latter, in spite of its parasites, may produce sufficient crops.

Extermination Treatment.—In districts far from invaded centres, where an invasion of the phylloxera is in its initial stage and shows itself in certain isolated spots, which threaten a whole vineyard, there must be no hesitation at the right moment to adopt the extermination treatment, which is capable of radically arresting the propagation of the insect, but it is necessary to sacrifice, at the same time, the attacked vines. This process, which is less and less used, since by the cropping treatment the plant may be maintained in a passable state of resistance, was in use, and even obligatory, in the borders of France, Switzerland, and Alsace-Lorraine, the vineyards of which, constantly threatened by destruction, were only preserved by these drastic measures. The extermination treatment is as follows: As soon as the phylloxera makes its appearance in a vineyard, the vine stems are cut down level with the ground, over the whole surface infected; these stems are burned on the spot. Before pulling up the stocks, holes 60 centimetres (24 inches) deep, 50 centimetres (20 inches) apart, in all directions, are made in the soil, and 50-100 cubic centimetres ($1\frac{3}{4}$-$3\frac{1}{2}$ fl. oz.) of carbon disulphide poured into each hole, which is plugged. If the soil be dry it is slightly watered, so that there forms on the surface a slight crust, which prevents the too rapid evaporation of the insecticide into the air. Three years after this disinfection all the stocks with their roots are pulled up and burned on the spot, after drenching them with tar. Fifteen days afterwards two new applications are made with weaker doses; 50 cubic centimetres per hole then suffice. In Alsace-Lorraine, where this treatment was prescribed, it was forbidden to replant the vine for ten years. Since the researches of Oberlin and Dufour have cleared the minds of the authorities, the vine can be replanted the spring following the treatment. These vines are, moreover, of extraordinary vigour, and yield from the fourth year a better crop than that obtained in untreated vineyards. If the extinction treatment was capable of retarding the

phylloxeric invasion for several years, it has never, on the other hand, prevented subsequent invasions, so that this very costly treatment has been abandoned.

Cropping Treatment.—Instead of destroying the vine by massive doses of $2\frac{1}{2}$ tons to 3 tons of carbon disulphide per hectare (1 ton to 24 cwt. per acre), its sanitary condition is to-day improved by an annual disinfection of 200-250 kilogrammes per hectare (176-220 lb. per acre), accompanied by more abundant manuring; instead of losing the precious time required to form a vineyard, the attacked vines are maintained in a good state of production. There are some that stand this treatment for thirty years, and are in perfect health. In Mouillefert's opinion, neither the cropping treatment, even in big doses, nor the submersion, nor other methods, give anything but incomplete results. Some insects always escape destruction because the distribution of a gas or a liquid through a layer of soil of unequal composition can never be perfect. If this treatment be not annual, it will be of no use, but annual treatment accomplishes perfectly the end in view, for it then annually frees the vine from the greater number of its parasites, and enables it each year to regenerate its atrophied roots, and to live, therefore, with its parasite without suffering too much from it. Every rational observer must therefore acknowledge that if this process be not perfect, and that plants grafted on vines immune to this insect have been the safeguard of the vine-grower, carbon disulphide has rendered great service by preserving the greater part of the French vines in a good state of production. The pure sulphide, or its solution, in water may be used.

Use of Pure Carbon Disulphide.—So that the treatment with carbon disulphide may give the desired result, it must be used according to the rules established by numerous experiments, and formulated by our learned professors. The accidents and mishaps that befel certain vine-growers were due to working during bad periods, and on unfit soil. Dr. Colas formulated in 1877 the rules for the use of carbon disulphide: (1) Treat the phylloxera as soon as it appears. (2) Treat the whole of the vines, and not the spots only. (3) Apply carbon disulphide in doses of 18-20 grammes per square metre, say $\frac{2}{3}$ of an oz. (wt.) per square yard. (4) Make injections between the stocks so as to place each of them between four holes, avoiding touching the roots with the pal. (5) Sink the pal only 15-20 centimetres (6-8 inches) deep. (6) Take care to plug the holes immediately after the operation. (7) Always take care to let heavy soils, which retain water a long time, drain after heavy rains and thaws. (8) Avoid treatment at the two seasons of the year when the sap begins to move. (9) Cultivate and manure the vines treated in a suitable manner. (10) Avoid treatment when frost is feared.

These rules have not been appreciably altered up to now. To create around the vine an atmosphere uniformly charged with vapours of carbon disulphide, uniform doses must be made to penetrate into the soil at equal distances. An arrangement of holes as uniform as possible must be chosen, and the treatment applied uniformly over all the extent of ground to be disinfected. Not less than 20,000 holes per hectare

(say 8000 holes per acre) must ever be made, nor less than 40,000 (16,000 per acre) in land only slightly permeable. A distance of 30-40 centimetres (12-16 inches) is generally kept from the foot of the vine, so as to avoid wounding the large roots. In many cases, however, deep injections can be made at 20 centimetres from the stock. The amount of sulphide injected per hole depends on the number of injections per square metre. At Libourne, for example, only 12 grammes is injected per hole, say 160 kilogrammes (352 lb.) per hectare (141 lb. per acre), instead of the dose of 200 kilogrammes (440 lb.) per hectare (176 lb. per acre) usually employed in the Rhone, where the vines produce in consequence of this methodical treatment as beautiful crops as before the invasion of the phylloxera. The dose to use depends, moreover, on the depth of soil and the age of the vine. If it be desired, like Monestier, Lautaud, and d'Ortomann, to bathe all the root system in a toxic atmosphere, three holes must be made 1·2 metre (4 feet) deep, the roots of certain vines being more than 1 metre (3·28 feet) in length. Cabanel and Degrully, however, advise not to go beyond a depth of 50 centimetres (say 20 inches). In compact soils 20 centimetres (7·8 inches) is enough. When holes are made in the immediate neighbourhood of the stock as the tendency is now, a depth of 8-10 centimetres (3-4 inches) is not exceeded. The greater number of vineyards is treated by the pal-injector. In large vineyards, however, the plough is employed as follows: In vineyards where the lines are a metre (3·28 feet) apart, two turns of the plough are given between the lines. Each line of treatment is 25 centimetres (10 inches) from each row of stocks. In the case of vines planted at greater intervals care is taken to maintain the distance of 25 centimetres from the stocks for the first line, the others are 50-60 centimetres (20-24 inches) from each other, but it is best not to approach the rows of vines too closely, for at 5-10 centimetres (2-4 inches) they suffer from the injections. Sulphuretting ploughs were introduced with great enthusiasm, but they did not give the results anticipated. That is, because in spite of their ingenious arrangement, the carbon disulphide cannot be introduced to any depth, without meeting and wounding the roots. The great advantage of these improved instruments consists in the fact that a man and a horse can treat ½ hectare (1¼ acre) with them in a day. The work, moreover, is very uniform as regards distribution and dose, especially with intermittent jet drainers. The latter, especially, have the great advantage of greatly facilitating the diffusion of carbon disulphide which is projected with force, and which is divided almost instantaneously. The efficiency of the treatment by carbon disulphide depends especially on the nature of the soil, and Degrully is of opinion that there exists for each soil a propitious moment favourable to the uniform distribution of carbon disulphide; this moment should be observed and chosen by the vine-grower. In permeable or sandy soil, cracked or too dry, the carbon disulphide will escape without producing its effect. But in compact moist or clay soils it does not spread enough and remains concentrated around the holes, thus destroying a portion of the roots in their neighbourhood and remaining without effect on a great part of the soil affected. The treatment must therefore be de-

ferred until the soil is neither too moist nor too cracked by the heat.

Although the painstaking observer will always be capable of utilizing the sulphide against the phylloxera in no matter what ground, its use is exclusively recommended in medium ground, neither too light nor too heavy, neither too moist nor too dry. Just as the treatment should never be applied after tillage, which by lightening the soil lets the sulphide evaporate too easily, it is necessary to wait fifteen days before trenching or working. The most favourable time for treatment depends, moreover, on the condition of the vine; although the latter does not suffer from this treatment when the dose is small, yet it is advisable to choose the time when the sap is at rest. October or November is preferably chosen for making injections; February and March are quite as favourable. So that the action of the sulphide be complete, the vine must be allowed to reconstitute its root system by giving it abundant manure, especially mineral. When the vine has been sulphuretted annually from the time of the invasion, it need not receive further care than what it usually gets.

Use of Carbon Disulphide Dissolved in Water.—The carbon disulphide used in the beginning of the phylloxeric invasion, having too often caused the death of the vine, it was thought that by dissolving the sulphide in water it would be less hurtful. The new method was proposed by Cauvy in 1875, and recommended in 1882 by Rommier, but it was not rendered practical until after the researches of Fafeur, C. Benoit, and Duponchel. A saturated solution, i.e. containing 0·5-1·2 per cent of carbon disulphide, is perfectly capable of combating the phylloxera; it kills it in twenty-four hours. The advantages of this method are that it is perfectly harmless to the vine even when it is in full vegetation, and that it can secure a uniform distribution in the soil. According to Degrully, the action of these solutions is the more perfect the more permeable the soil. Under this form the sulphide acts quite as well as potassium sulphocarbonate and has the advantage of being much cheaper; 200 lb. of sulphocarbonate employed in the same conditions as 10 gallons of carbon disulphide, in 1 per cent solution, do not give so good a result. To prepare a solution of sulphide, Fafeur frères have designed an apparatus capable of spreading water on a layer of carbon disulphide, in a closed reservoir. A current of water flows through a pipe of suitable dimension drawn out to a point. The pressure obtained by the drawing out and the speed of the current is exerted on the upper part of a receiver full of water and sulphide which, owing to its density, always occupies the bottom of the receiver. This pressure is transmitted to the receiver by two orifices. The solution is thus produced under pressure in a closed vessel by the junction in a pipe of two jets of sulphide and of water, the intensities of which are always proportional to each other. By opening the gauge taps the dose is regulated from 0·5-1·2 per cent. The sulphuretted water is carried by buckets or a long watering pipe into small holes specially dug round the stocks. These holes should be well made, horizontal, and separated from each other by mounds of earth so that the liquid is spread uniformly in the

soil. Working on a large scale steam pumps carry the sulphuretted water several kilometres (kilometre = 0·625 mile) by means of a galvanized iron pipe. The average amount of sulphuretted water for each stock is 20 litres (4·4 gallons), and the solution contains 0·5 per cent of sulphide in summer and 0·7-1 per cent in winter. The soil should be returned to its place as soon as possible after treatment.

Insecticide Irrigations.—These examined and recommended by Duponchel represent the most improved and rational system. Underground irrigation, already very efficient in itself especially when manure is added to the water, appears to be a method of treatment that can be usefully applied in the treatment of the vine attacked by the phylloxera. But although the ordinary treatment enables the state of diseased vines to be improved, it could not in itself constitute a sufficient remedy to kill the phylloxera and annul the disastrous effects of that insect. Insecticide irrigations have a very salutary effect on vines and fulfil the end in view. Carbon disulphide cannot, in fact, suffice by itself alone to re-establish the health of a diseased vine during drought, or when root growth is stopped. To attain this salutary effect it is necessary to follow up the injections of sulphide, which in destroying the phylloxera suppress the evil by an underground irrigation which causes the effects to disappear by fortifying the roots and giving new vigour to the vine. It is better to combine the two treatments in a single one and to apply simultaneously to the plant, along with the water carbon disulphide and the necessary manures. This method of diffusing the insecticide throughout the whole depth of the soil, in a dose which it is known cannot injure the plant, produces an excellent effect. The irrigations ought to penetrate 20-24 inches into the soil. They require 1000 cubic metres of water per hectare, say 100 kilogrammes (88 lb. per acre) of sulphide, which represents 30 cubic metres (6600 gallons) of sulphide vapour (2640 gallons per acre). A stronger dose would injure the vine, especially during the epoch of vegetation, which lasts eight months. Insecticide irrigation is differentiated from the sulphide treatment by the fact that the first can be applied in the spring, in summer, and in autumn without prejudice to the plant, whilst the latter can only be done during the repose of vegetation. The irrigation water is brought to the culminating point of the vineyard to be treated. At this point it is mixed with the carbon disulphide in a tank, called the bubbling tank, and arranged so that the water charges itself with carbon disulphide without being able to carry away with it what has not been dissolved. The same bubbling apparatus used to dissolve the sulphide may serve for dissolving the manures, so that the water entrains them and distributes them throughout the whole extent of the diseased vineyard. To produce good results the irrigation should be underground and the surface of the soil should be maintained constantly dry and friable by tillage or by hand hoeing, carried out after watering, and renewed each time that rain has strongly packed the soil. To secure good underground distribution it is necessary to lighten the soil by tillage and to open around each stock a small ordinary stripping basin. These basins are connected with each other so that they can be filled in succession.

If the tanks have only the slight slope required to ensure the flow of water without a gush, the water introduced into the basins will filter into the soil without moistening the surface layer. As soon as the liquid is completely imbibed, the holes are filled with dry earth and the soil is soon afterwards tilled and hoed. The large quantity of water which these irrigations require renders the treatment almost impossible. But when a spring with an output of a litre a second (13·2 gallons a minute) is available the quantity of water produced suffices to irrigate 10 hectares (25 acres). Underground insecticide irrigations, although useful in all cases, are particularly favourable in the hot countries of the South of France, where it is necessary to ameliorate the hygienic conditions of the vine by moisture to enable it to reconstitute its root system after being freed from the insect which caused the disease.

Schizoneura lanigera, Hausm. (woolly aphis).—The disinfection of the branches, as is done by applying various insecticides, is not enough, for there exist underground hot-beds of infection which re-infect the crown of the tree. Carbon disulphide, used in injections round the plant, forms an excellent means of destroying the aphis living on the roots. Taschenberg and Goethe have recommended the use of carbon disulphide to destroy the colonies existing above ground. They advise for this purpose the use of a stick, to the extremity of which a lump of cotton-waste dipped in carbon disulphide is fixed. The woolly aphis can thus be destroyed at all seasons without injuring the apples. To get a good result the colonies must not be overlooked, and to recommence the treatment some time after the first. Targioni and Sorauer recommend soap emulsions for the same object, the first a 2 per cent carbon disulphide one, and the second a 4 per cent one. Gold's liquor, recommended for the destruction of the woolly aphis, consists of 20 grammes of [spirits of ?] turpentine, 20 grammes of carbon disulphide, and 60 grammes of curdled milk. Amongst the underground ground lice that often occasion great damage are the—

Schizoneura Grossulariæ, Schule, which sucks the roots of the gooseberry.

Aphis Persicæ niger (the peach tree aphis).—This aphis causes ravages in peach orchards in America.

Tychea Phaseoli, Pass.—The presence of which, on the roots of haricots, cabbages, and potatoes, sometimes causes them to perish. All these insects may be combated like the phylloxera. The lice which sometimes damage certain plants are successfully combated when it is possible to cover the plant with an awning or a cloche (bell-shaped vessel) under which a few grammes of carbon disulphide are laid. According to Smith all the lice are killed in an hour. Even after twenty-four hours' treatment at the ordinary temperature the plant does not suffer. Soap emulsions, 2-4 per cent, have likewise been applied in a general way, but these latter, which sometimes succeed perfectly, may completely roast the leaves, chiefly those that have been wounded.

Coccides (cochineals, kermes).—In a general way the *Coccides* resist carbon disulphide to a greater extent than the *Aphides*, but they do not

resist a sulphuretted atmosphere. By destroying the cochineal the fumagine (smut of fruit trees) is arrested.

Coccus Vitis, L., syn. *Pulvinaria Vitis* (red cochineal of the vine); *Dactylopius Vitis* (white cochineal of the vine).—Targioni-Tozzetti and Pastre recommend carbon disulphide emulsions.

Diaspis pentagona, Targ.-Tozz. (mulberry kermes).—Franceschini recommends for the disinfection of buds to place the branches before detaching them from the tree in an atmosphere of carbon disulphide. With this end in view, the end of the branch is placed in a tight cylinder, where it is left some hours in contact with a toxic atmosphere. This treatment whilst disinfecting the buds is not injurious to them.

Orange scale insects: (1) *Aspidiotus Limoni*, Sign; (2) *Mytilaspis flavescens*, Targ.-Tozz.; (3) *Chrysomphalus minor*.—The first, especially injurious, in Italy induces the fumagine, the last two, imported from America, dot the organs attacked with small yellow spots. Hoffmann recommends spraying with carbon disulphide emulsions, containing 2 per cent of soap and 2 per cent of sulphide. Belle advises the destruction of these parasites in greenhouses and pot plants by covering the latter with an awning, and producing a sulphuretted atmosphere, 120 grammes of sulphide sufficing per cubic metre.

Mammals.—The rodents which cause damage, such as the mouse, field mouse, ground squirrel, rat, and even the mole, may be destroyed by pouring carbon disulphide into their burrows and stopping the orifices of their nests. It takes 20 grammes (say $\frac{3}{4}$ oz.) for the *Mus sylvaticus*, L., Borghi; 10 grammes (say $\frac{1}{3}$ oz.) for the ground squirrel (*Spermophilus citillus*, Bajor); for rats 60 grammes (say 2 oz.) are necessary. The most radical method consists in steeping rags in carbon disulphide and in inserting them deeply into their holes, which are afterwards plugged with plaster, mortar, or a plug of hay coated with potters' clay.

CHAPTER IV.

SULPHUROUS ACID—SULPHURIC ACID (OIL OF VITRIOL)—CHLORINE —HYDROCHLORIC ACID—NITRIC ACID.

6. Sulphurous Acid, SO_2.—**Preparation.**—This gas is prepared on the large scale by the oxidation of sulphur. When sulphur is inflamed in contact with air this product burns and is converted into sulphurous acid. Pyrites, or sulphide of iron, which is roasted at a great heat, may also be used to obtain this same acid. That is the process most usually employed. The gas is led into a gasometer, where it is liquefied by cooling.

Properties.—Sulphurous acid is colourless and very fluid. It boils at 8° C. below zero; its density is 1·45. Sulphurous acid is not combustible. Its use is, therefore, attended with no risk of fire. Respired in large quantities it induces suffocation, but in small quantities it is not injurious to man.

Action of Sulphurous Acid on Plants.—All plants, without exception, suffer in an atmosphere of SO_2. The leaves absorb this gas, very much attracted by water, and hydrate it. Almost all the sulphurous acid is retained there, and they are the first to suffer. A very small quantity then passes into the wood of the plant. Under the influence of the solar radiation the hydrated sulphurous acid is transformed into sulphuric acid, with liberation of sulphur, according to Loew's equation:—

$$\underset{\text{Sulphurous acid}}{3H_2SO_3} = \underset{\text{Sulphuric acid}}{2H_2SO_4} + \underset{\text{Sulphur}}{S} + \underset{\text{Water}}{H_2O}$$

The numerous analyses made on dead plants, after the absorption of sulphurous acid, all, in fact, give abnormal quantities of sulphuric acid.

Wislizenus, who widened the question by very conclusive experiments, believes that sulphurous acid, absorbed by the plant, has no injurious action on the latter, except the plant be full in the light, and especially in full sunlight; in darkness the action is *nil*, although there is absorption of the gas, and in winter the action is very attenuated. According to the experiments, an atmosphere containing a proportion of $\frac{1}{1000000}$ of its volume of sulphurous acid kills fir-trees (*sapins*) in about four weeks if they are in contact with this air in full daylight, but these same firs do not appear to suffer if the experiment be repeated in darkness, even if the atmosphere contain $\frac{1}{500000}$ of sulphurous acid. It is thus evident that sulphurous acid is only converted into sulphuric

acid under the action of light, and it is the latter acid which is injurious to plants. Agreeing with Von Heine, Wislizenus concludes that sulphuric acid destroys the chlorophyll of the plant, and that it thus acts in a manner unfavourable to assimilation. Sulphuric acid dries the cell-walls and renders them impermeable. Only the tissues in contact with the fibro-vascular bundles remain fresh and green, whilst the others wither, brown, or bleach. In that lies the characteristic symptom of these poisonings. According to Von Heine, the transpiration of the poisoned leaves, the cell-walls of which have become impermeable, is less than that of healthy leaves. As the activity of transpiration expresses the production of matter, the leaf assimilates less, the plant remains stationary, and finally dies. The greater the amount of sulphurous acid absorbed, the more intense the sun, the greater the heat, and the drier the air, the more quickly are these symptoms produced. All leaves, however, do not absorb the same amount of sulphurous acid in the same atmosphere. With equal leaf-surface, those of conifers absorb much less of this gas than those of deciduous trees and herbaceous plants. It was believed that the gas being absorbed by the stomata of the leaf, the quantity retained would be proportional to their number, but experience has shown that it is not so, for leaves absorb this gas quite as well by their upper surface. The herbaceous plants are ranked, according to their sensitiveness to sulphurous acid, between the conifers and the deciduous trees. The leaves of the *papilionaceæ* (pea tribe), potatoes, cereals, and meadow grass, commence to fade and to brown at their extremities after exposure of two hours in air containing $\frac{1}{10000}$ sulphurous acid; in an atmosphere containing only $\frac{1}{60000}$ of this gas desiccation does not occur until after fifteen to twenty hours. For leaves of deciduous trees to perish the air must contain $\frac{1}{10000}$ to $\frac{1}{20000}$ of sulphurous acid. Conifers in general, and especially firs, do not support air containing more than $\frac{1}{10000}$ to $\frac{1}{20000}$ of this gas, especially in the neighbourhood of factories. This small quantity of sulphurous acid necessary to cause a pathological condition of the plant is the reason why each factory chimney must be regarded as a perpetual hot-bed of infection. The smoke from the combustion of coal contains on an average 0·01 to 0·02 of sulphurous acid gas. The danger is obviated if the smoke is sent into the air by chimneys measuring 20 metres, say 65 feet, in height. The following, for example, shows the deterioration undergone by a field of oats situated near a coke factory. One thousand seeds of normal oats ought to weigh, on an average, 25-29 grammes; 1000 grains in the sickly field only weighed 14·76 grammes. Both the grain and the straw in this field were analysed, and in both instances a large amount of sulphuric acid was found. Such damage to crops is particularly intensified around chemical factories, chiefly sulphuric acid factories, where pyrites is roasted, and zinc factories, in which blende, zinc sulphide, is calcined. The deadly action of the sulphurous acid sent into the air by these factories manifests itself at great distances. Forests 5 kilometres, say $3\frac{1}{4}$ miles, away still suffer from their proximity. A zinc works calcining 50 tons of blende disengages 37,000 hectolitres (814,000 gallons) of sulphurous acid. It

will be seen that this amount of toxic gas, if not utilized, may carry devastation to great distances. Many observations have been made on this point, and it is found that near (such) factories the leaves of the fir (? spruce) fall, those of the pine and larch, more resistant, only brown at the point, and the trunk blackens; conifers, in general, do not resist long. Deciduous trees, fruit trees, among others, lose their leaves and do not produce fruit, because the sulphurous acid sterilizes their flowers. The cornfields are sickly, patchy; the brown-coloured ears contain no grain. Haricots and cabbages are spotted white and suffer much. The dead leaves of the potato shrivel and blacken. The meadows remain sickly and turn brown. These sickly plants have been analysed with great care by Morren, Stockhardt, Von Schroder, Freytag, and Konig. They found that they all contained an abnormal dose of sulphuric acid. It is important to insist on these facts, so as to show the injurious action of sulphurous acid on plants. Knowing this fact it is an easier task to contradict the opinion generally held that sulphur acts on fungi by its conversion into sulphurous acid. If it were so our vineyards, instead of becoming more vigorous by sulphuring, would perish, since an infinitesimal quantity of acid suffices to roast plants, and fructification, instead of being stimulated as is the case, would be diminished.

Action on Fungi.—It follows from observations made on plants that those which contain chlorophyll are more sensitive to the action of sulphurous acid than those deprived of it. Sulphurous acid cannot therefore be used to destroy fungi.

Action on Insects.—To stifle insects the air must be saturated with SO_2. Great care must therefore be taken in using this gas so as to avoid its deadly action on plants. The great delicacy of the operation renders it less and less popular, hence the clochage of the vine still in use in certain districts is gradually being replaced by scalding. The phylloxera does not persist for twenty-four hours in an atmosphere of this gas of 1 in 60 or 1 in 100. Mouillefert tested it in the soil against phylloxera but without result. Moisture and the nature of the soil destroy its toxic properties.

Use in Diseases Treated by SO_2 in the Open Air.—*Gum Disease.*—Swingle and Webber who examined the action of different chemicals on this disease recommend to cure it, to clean the wounds and coat them with an 18 per cent solution of SO_2.

Anthonomus Piri, Boh., *Anthonomus Pomorum*.—These formidable destroyers may be removed in May by SO_2 fumigations (Poupinel). A dish of burning sulphur is moved about under the branches, or rags dipped in molten sulphur and then lit. The trees should not be fumigated with SO_2 when in blossom, as the flowers would be sterilized even if the contact was short and the acid in very small quantity. Such fumigations also asphyxiate the grubs injurious to fruit trees, who know how to shelter themselves from spraying in the common nests which they spin. The most injurious are *Hyponomeuta Malinella*, Zell. (small ermine moth) and *Liparis chrysorrhaea* (brown tail moth). The grubs of these butterflies are only sensitive to fumes of SO_2. Dufour proved by trial that liquid SO_2 does not act on the

grubs, and that even a 20 per cent solution does not kill those of the *cochylis*.

Phylloxera vastatrix (vine phylloxera).—The phylloxera dies if exposed for twenty-four hours in an atmosphere containing 1 per cent of SO_2. Hence it was thought the injection of SO_2 in the soil would destroy this injurious insect. Aman Vigié recommended injections into the soil of a mixture of sulphur and sulphur fumes from the beginning of the phylloxera invasion. Henneguy remarked that when this treatment was applied in summer the spread of the disease was circumscribed, and although this process may be insufficient to free the vine entirely from its parasite, it destroys it to such an extent as even to allow the vine to thrive. Mouillefert examined the effect of SO_2 both as gas and in solution, as well as its different salts. He found that sulphites are quite powerless against the phylloxera. As to gaseous SO_2 it has no action on insects near the surface of the soil because this gas, with a great affinity for water, can never penetrate deep enough into the soil.

Mus amphibius, L. (Rat).—M. A. ter Mer advises the use of SO_2 to kill rats. Rags are dipped in molten sulphur and petroleum, these are inserted into the burrows and lit. It requires about $\frac{1}{2}$ lb. of sulphur per burrow. Taschenberg dissents; he found that this method failed, even if the gas is driven far into the burrows by means of special bellows.

Use of SO_2 in Closed Spaces.—The action of SO_2 is deadly to insects when the air is saturated with it. It is used especially in granaries against the Coleoptera and Lepidoptera injurious to the stored grain. It has also been used on small trees which can be covered with a tent or a cloche. The last method is used especially to combat the *cochylis* of the vine.

Mycogone perniciosa (mole disease of the mushroom bed), *Psalliota campestris*, L.—Constantin and Dufour found that the spores of the *Mycogone* are killed by prolonged contact with SO_2. Mushrooms are in no way injured in an atmosphere containing this gas, even if the fumigation lasts twenty-four hours.

Hops.—The preservation of stored hops is not always an easy matter. Disinfection with SO_2 does not always give the result expected. Behrens found that if SO_2 be incapable of killing the germs of the parasite which infest hops, it has a good effect on their quality, which it alters for the better. But it is chiefly against the invasion of Coleoptera into granaries and on the vine that SO_2 does good work. Amongst these insects are :—

Calandra granaria (or wheat-weevil).—As a curative method fumigation with SO_2 is used. The doors and windows of the granary are closed; sulphur is then ignited in a vessel placed on a support above a sheet of iron; 1500 grammes (3·3 lb.) of sulphur with 100 grammes (·22 lb.) of saltpetre, suffice to disinfect a space of 50 cubic metres. The granary is left closed for twenty-four hours, then it is cleansed with a 2 per cent solution of corrosive sublimate. The same process is used to destroy *Microlepidoptera*, the grubs of which ravage grain and flour granaries.

Sitotraga cereallela (grain mite).—So that the SO_2 may penetrate well into the heap of wheat and kill all the grubs, Bernard Saint Ubery burns the sulphur in chafing dishes around which the grain is piled in heaps. To destroy butterflies the process used against the *Calander* gives good results. It suffices to place 1 inch to $1\frac{1}{2}$ inch of sulphured wick on slates laid on the heap of wheat, and to set fire to the wick. By analogy it was thought possible to destroy by the same gas the grubs which live in flour.

Asopia farinalis (flour mite).—The process recommended by Debray consists in burning in closed vessels 60 grammes of sulphur per cubic metre of flour; the method was regarded as obnoxious, the flour being rendered unfit for bread-making; Balland found this flour, whilst presenting no visible alteration, is appreciably altered in contact with sulphurous acid. The gluten has lost the valuable properties required in baking. It is recognized, in fact, that gluten gains in value by contact with alum, common salt, or blue vitriol, but that it cannot stand the action of sulphurous acid, SO_2, nor sulphuric acid, SO_3, nor sulphuretted hydrogen, SH_2. To destroy the tinea of grain, SO_2 must not be used, but insecticides like CS_2.

Tortrix or *Pyralis vitana* (pyralis of the vine).—The grubs hibernating in the fissures of the bark of the vines can be killed by SO_2. The process employed in the South of France is known by the name of *clochage*, or sulphuring of the vine. After pruning the vine, each stock is covered by a zinc cloche, or half a petroleum barrel, under which 20-25 grammes of sulphur (say $\frac{3}{4}$ oz.) are burnt in a saucer. The SO_2 formed soon saturates the air under the cloche, and stifles the grubs sheltered in the interstices of the bark. The operation should not last longer than five to ten minutes, a more prolonged action having a deadly effect on the vine. A workman provided with twenty cloches can sulphur 1000 stocks per day. The cost is 48 francs per hectare if brimstone be used and 75 francs if wicks be used, say 15 and 24 shillings per acre. It is thus cheaper to use brimstone. It is a very delicate operation, which may well be replaced by scalding, but its use is still widespread. So that it may succeed, it must not be done when the soil is moist, for the SO_2, instead of saturating the air, would be absorbed by the humidity in the soil. Clochage kills at the same time as the pyralis the vine cochineal and the red spider. Reh found that all coccides shielded Homoptera, such as *Diaspis*, *Aspidiotes*, *Lecanium*, *Ceroplastes*, and cochineals, which resist all insecticide spraying, may be destroyed by SO_2 fumes. The fruit trees are covered with a tent, and sulphur burnt therein, observing the same precautions as in the clochage of the vine.

7. **Sulphuric Acid,** H_2SO_4.—Sulphuric acid is obtained by passing a mixture of oxygen and sulphurous acid over spongy platinum or platinized asbestos, heated to between 250° C. and 500° C. (482°-932° F.). The vapours of SO_3 disengaged are led into a receiver surrounded by a freezing mixture, where they condense. The process of manufacture usually adopted is to oxidize sulphurous acid by nitric acid vapours and to hydrate the vapours in lead chambers. The necessary SO_3 is obtained by "burning" iron pyrites in presence of an excess of air.

Natural Occurrence.—H_2SO_4 is widely distributed in nature as sulphates of lime, $CaSO_4$, of baryta, $BaSO_4$, of soda, Na_2SO_4, and of potash, K_2SO_4, etc. It is found in the free state in some springs in the neighbourhood of volcanoes.

Properties.—The commercial acid of 66° B. (168° Tw.) is a colourless, odorous, viscous, oily liquid of sp. gr. 1·84. When water is mixed with the acid so much heat is developed that it may become dangerous if the water is added to the acid. Care must therefore be taken in diluting the acid with water to run the acid gently into the right amount of water with constant stirring. H_2SO_4 has a great affinity for water, and rapidly carbonizes organic matter.

Action of Sulphuric Acid on Plants.—This acid exerts a corrosive action on the organs of the plants touched by it. A very small dose of this acid (even dilute) destroys the chlorophyll and degenerates the cell-walls, thus giving rise to a profound disturbance in the life of the plant.

Transpiration is less abundant, and that of itself diminishes or even abolishes completely the production of synthetic organic matter, the leaves brown, wither, fall, and the growth of the plant is visibly arrested. If the action of this acid on a plant be prolonged it soon dies, for the acid penetrates rapidly into the interior of the trunk, and the circulation of the sap is stopped. The same result occurs when a plant is in contact not only with the dilute acid but also with sublimed sulphur which contains H_2SO_3, and under the influence of sunlight is converted into H_2SO_4 in the leaf itself.

Action of Sulphuric Acid on Fungi.—Plants not containing chlorophyll suffer much less than green plants in contact with H_2SO_4. However, owing to its hygroscopic nature, H_2SO_4 diluted to 0·5 per cent exerts a corrosive action on fungi. Laboratory trials made by dipping the spores into a drop of H_2SO_4 diluted to 0·5 per cent show that such dilute acid destroys in most instances the vitality of the spores, provided that its action be sufficiently prolonged. In practice the 0·5 per cent acid is quite inadequate to destroy the spores and mycelium of fungi, and stronger, sometimes even the 168° Tw. acid must be used. It will be easily seen that at that degree of concentration H_2SO_4 cannot be put in contact with the leaves of plants, and that it should be limited to applications on the trunk, or to disinfect certain seeds; in a wood it can only be used when there is no active plant growth. Under such conditions, plants do not appear to suffer from the sulphuric acid treatment. When H_2SO_4 is used in combination with anti-cryptogamic metallic salts, its corrosive properties become valuable, because in attacking the protective membrane of the parasites it enables the poison to reach and destroy them more readily. In combination with green vitriol in the winter treatment of anthracnose of the vine, sulphuric acid is in current use, and of great service.

Use against Parasitic Fungi.—Sulphuric acid has been recommended for some years to wash seeds to free them from the spores of different fungi which might be brought on to cultivated land. Noel found in 1866 that steeping in the 0·5 per cent acid sufficed to free seed-corn from anthracogenous parasites. He stirred up a hectolitre

(2¾ bushels) in 22 gallons of 0·5 per cent acid, and sowed immediately afterwards. This method has since been tested by specialists of high reputation and found deficient. Kuhn has shown that not only was the 0·5 per cent acid an anodyne for the spores, but had the drawback of being more injurious than sulphate of copper. The injurious action of the acid on cereal grains does not make itself felt for some time. Such seed-corn always retaining a little sulphuric acid cannot dry up completely and rot. This drawback may be avoided if care be taken to wash the seed in milk of lime immediately after steeping in the acid. In fact, Boiret found that the spores of bunt were not completely destroyed after a twenty-four hours' steep in a 5 per cent acid, and that a 20 per cent acid destroys the grains of wheat without killing the germs of the disease, even if steeped six hours therein. All cereal grains are thus sensitive to the action of H_2SO_4; however, amongst the different species of wheat there are some which stand the acid better than others.

TABLE XI.—*Effect of Steeping Seed Wheat for Different Lengths of Time in Dilute Sulphuric Acid on Germinative Capacity per cent.*

Sulphuric Acid.	*Duration.*	*Golden Drop.*	*Garter.*
1 per cent . .	24	—	18
2 ,, ,,	12	40	14
2 ,, ,,	8	—	18
5 ,, ,,	2	90	—
5 ,, ,,	1	92	60
Steeped in water	—	—	90

It follows that this acid does not possess the requisite properties to replace blue vitriol in the pickling of seed corn. The only seeds that can stand steeping in the acid are beet-seeds, which are surrounded by a protecting sheath which enables them to stand steeping in acid of 66° Be. (168° Tw.) without their germinative capacity being diminished. This protecting sheath acts as a shelter to the germs of fungi and bacteria of the most diverse nature, such as *Phoma tabifica*, Prill. et Delacr.; *Pythium de Baryanum*, Hesse; *Bacillus mycoïdes*, *Bacillus butyricus*, *Proteus vulgaris*. As soon as the radicle and cotyledons of the beet appear these fungi invade them, disturb the normal evolution and induce rot. Hiltner found that the 30°-35° Be. acid will destroy the germs of all these parasites. Linhart recommends 66° Be. (168° Tw.) acid in which the seed is steeped half an hour, then washed ten minutes with a jet of water, then the seeds are dipped into milk of lime, and all that now remains to be done is to wash the seed for four hours in running water. The seeds so treated are in no wise injured. Their germinative capacity is increased; they spring up more rapidly and in larger quantity, and the disease germs are completely destroyed. For reference purposes a description is here given of the researches published on the resistance of spores of different fungi to dilute H_2SO_4. These laboratory trials were made by incor-

porating the spores of rust and of caries with a drop of dilute sulphuric acid, which after being a certain time in the acid were sown or examined by the microscope. In 1872 Kuhn examined the action of sulphuric acid on the spores of the caries of wheat, and he found that acid of the same strength is not capable of killing in the same time the different spores of caries. A 5 per cent acid acted thus :—

TABLE XII.—*Showing the Action of Dilute Sulphuric Acid of 0·5 per cent Strength on the Spores of Oats and Wheat.*

Duration of Action.	*Oats.*	*Wheat.*
1 hour	Numerous living spores .	Numerous living spores
6 hours	Living spores less numerous	,, ,,
8 ,,	Very few living spores .	,, ,,
10 ,,	All spores killed . . .	,, ,,

In 1892 Wuthrich examined the action of different acids, compared with that of metallic salts, on the spores of—

Ustilago Carbo, Tul. (smut of grain crops).—In a 0·49 per cent sulphuric acid all spores are killed after fifteen hours' action at 20°-22° C. An acid of 0·049 greatly prevents the formation of zoospores, whilst acid of 0·049 per cent has no longer any injurious action on the spores themselves. In 1895 Herzberg examined the different rusts, and submitted their spores to the action of sulphuric acid of various strengths. The spores of *Ustilago Jensenii*, Rost., the smut of barley, were found to be the most resistant. To kill these spores they must be steeped fifteen hours in 3 per cent acid, whilst those of the other *Ustilaginæ* are killed in much weaker acid. Moreover, the dilute acid has not the same action on the spores of the same species but of different ages; the mortal dose is given in the following table :—

TABLE XIII.—*Showing the Strength per cent of Sulphuric Acid required to Kill the Spores of Smut of Barley, Oats, and Wheat of Different Ages.*

Species.	*Strength of Sulphuric Acid. Per Cent.*	
	Old Spores.	*Young Spores.*
Ustilago Jensenii, Rost.	1-1·5	2-4
,, Avenæ, Rost. . . .	0·5-0·75	0·5-0·75
,, perennans, Rost. . .	0·1-0·25	0·25-0·5
,, hordei, Bref. . . .	0·5-0·75	0·5-0·75
,, tritici, Jens. . . .	0·5-0·75	0·25-0·5
Circumambient temperature . .	15°-18° C.	23° C.

Puccinia graminis (black stem rust, summer wheat mildew); *Puccinia Rubigo-vera*, D. C. (orange leaf rust, spring rust of corn);

Puccinia Coronata, Corda (the crown rust of oats).—Wuthrich made a comparative examination of these three rusts, by submitting in turn their uredospores and their æcidiospores to the action of the more or less dilute acid. The time of steeping was fifteen hours, and the temperature 20°-21° C. (68°-69·8° F.). The uredospores resisted an acid ten times stronger than the æcidiospores; acid of 0·0049 per cent does not act on uredospores of 0·049 per cent; its action begins to make itself felt, but it is not until 4·9 per cent acid is used that all vitality is removed from the spores. The æcidiospores are completely destroyed, and in the same conditions, by acid of 0·49 per cent strength. The uredospores of the rust of cereals would appear to be the spores most resistant to the action of sulphuric acid, as they likewise are to anti-cryptogamic salts. Hitchcock and Carleton have, however, prevented the uredospores from germinating, by steeping them for seventeen to nineteen hours in 0·1 per cent acid.

Claviceps purpurea, Tul. (ergot of rye).—The action of the acid on this disease was examined by Wuthrich, who found that 0·049 per cent acid attenuated the germination of the conidia, but it required steeping for fifteen hours at 20°-21° C. (68°-69·8° F.) in an acid of 0·49 per cent to stop this germination completely. Wuthrich, who examined the action of the acid on the spores of *Phytophthora* and of *Peronospora,* found these latter much more sensitive than those of the black and red rust of cereals.

Phytophthora infestans, De By. (potato disease).—Acid of 0·049 per cent perceptibly diminishes the capacity of the conidia to form zoospores. It may be entirely arrested by destroying the conidia, by using 0·049 per cent acid for fifteen hours at 19°-20° C. (66·2°-68° F.).

Peronospora Viticola, De By. (vine mildew).—The conidia and the zoospores of this parasite behave like those of the *Phytophthora*; acid of 0·049 per cent completely annihilates them in fifteen hours at 20° C. (68° F.). In 0·0049 per cent acid the formation of zoospores may be restricted, and even suppressed, without the conidia being killed. The latter then germinate and produce directly a germinative tube. The deleterious action of sulphuric acid on the germs of mildew has caused it to be used for the winter treatment of wine stocks. Bouchard got good results by treating the vines in the spring after pruning with a 10 per cent acid. During three years the vines received no other treatment than the above, and the disease did not reappear. McAlpine came to the same conclusion, and found this treatment always to give good results. Millardet, on the other hand, combats this opinion, and considers treatment with sulphuric acid as very injurious to the vine. The author nevertheless sides in his opinion with the first observers. Acidulated solutions of green vitriol used everywhere against anthracnosis cause no injury to the stocks.

Gloeosporium ampelophagum, Sacc. (grape rot).—To combat this disease the utility of the acid was found empirically. It is not, it must be understood, a question of treating this disease during the growing period, for sulphuric acid, or even the acid mixtures, would have a deplorable action on the stocks. The acid is used exclusively in winter to cauterize the spots hollowed out of the young wood,

sorts of canker produced by the anthracnose containing spores which should be considered as hot-beds of infection. The remedy most generally used is a 50 per cent green vitriol solution, but to intensify its action it is associated with sulphuric acid in the proportion of 1 to 2 per cent. Fifty kilogrammes, say 1 cwt., of green vitriol are taken, and 1 litre, say 4 lb., of sulphuric acid are poured on to it and the whole dissolved in 100 litres (22 gallons) of hot water. However, many vine-growers limit themselves to sulphuric acid and regard it as sufficient to circumscribe the disease. Bouchard, Debray, Berlese, and McAlpine are unanimous in eulogizing the good results of this method, which according to McAlpine is of current use in Australia. It is certain that it kills not only the spores of this disease but also those of the oidium. It is important to operate before budding-time, so as not to injure the growth. It is necessary to imbibe the stems, the runners, and all the wood, and even the eyes. The latter, owing to this treatment, blossom, it is true, some days later than non-treated vines, but this in many cases is an advantage. The coat may be applied with a brush or with a woollen rag.

Sphærella Fragariæ, Sacc. (strawberry leaf blight).—Galloway recommends the following energetic treatment to destroy this disease : Spray the strawberries after gathering the crop with 2 per cent acid, which kills both the old leaves and the spores of the parasite. The new leaves which spring up are perfectly healthy. Tyron found this treatment to give as good results as bouillies bordelaise or alkaline sulphides.

Cuscuta (Dodder).—Wagenblicher found that 0·5 per cent acid killed dodder, but when used on fields of trefoil and lucerne against *Cuscuta Epithymum* the burning of the plant injured the crop. As a weed-killer on walks sulphuric acid is defective. The effect is immediate but the weeds soon sprung up as vigorous as ever. Finally, sulphuric acid has been prescribed against potato scab. Wilfarth, acting on the principle that ashes and lime induce this disease, tried to produce a contrary effect by spreading sulphuric acid on the fields. He therefore spread sulfarine, a mixture composed of magnesium sulphate and of 15 per cent sulphuric acid. The results were decisive, as shown in the following table :—

TABLE XIV.—*Showing the Action of Different Doses of Sulfarine* (*kieserite*) *containing* 15 *per cent of Sulphuric Acid on the Potato Disease.*

Dose.	*Crop.*	*Per Cent Diseased.*
Blank	76 potatoes of which	80 diseased
2 kg. of sulfarine per m^2	77 ,, ,,	60 ,,
7 ,, ,,	76½ ,, ,,	40 ,,
10 ,, ,,	73 ,, ,,	25 ,,
14 ,, ,,	73 ,, ,,	20 ,,
18 ,, ,,	65 ,, ,,	10 ,,
30 ,, ,,	50½ ,, ,,	5 ,,

The disease is, in fact, considerably diminished by this treatment, but the dose of 14 kilogrammes of sulfarine per square metre must

not be exceeded, for there would be the risk of too small a crop which would be as great an evil.

Use of Sulphuric Acid against Insects and Worms.—*Tylenchus Tritica* [Bastian] (eel-worm of wheat).—This is a microscopic worm which causes the blight known in France as Nielle de Froment [and in Great Britain as "Ear Cockles," "Purples," "False Ergot," "Galls of Wheat Eel-worms"]. Davaine in 1889 recommended steeping the affected grain in 0·5 per cent sulphuric acid for twenty-four hours, but this method has the drawback of injuring the grain.

Tortrix Vitana (pyralis of the vine).—The winter treatment against anthracnose of the vine by sulphuric acid, not only destroys the spores of the most formidable cryptogamic parasites, but according to Debray it also destroys the grubs of this butterfly which pass the winter in the interstices of the bark. According to the same observer the vine cochineal *Dactylopius Vitis*, which passes the winter fixed against the wood, may be destroyed by spraying with 10 per cent acid after the fall of the leaf. The acid employed under like conditions to destroy the *Schizoneura lanigera*, Haus, did not give the result expected. To kill *wasps* it suffices to pour 10-20 per cent acid into the nest.

8. Chlorine, Cl_2.—Chlorine is an element widely distributed in nature in combination with certain metals—sodium, potassium, magnesium.

Preparation.—By the action of aqueous hydrochloric acid on manganese dioxide.

MnO_2	+	$4HCl$	=	$MnCl_2$	+	$2H_2O$	+	Cl_2
Manganese dioxide.		Hydrochloric acid.		Manganous chloride.		Water.		Chlorine.

Use.—This gas, of some use to kill fungi, is so poisonous to plants that its use is limited to saprophytic fungi, such as—

Merulius lacrymans, Schm. (dry rot of wood).—As a remedy chlorine is the subject of a German patent, D.R.P. 76877, according to which good results are obtained by piercing boards with holes into which chlorine is introduced; these holes are then stopped up hermetically.

9. Hydrochloric Acid, HCl.—**Preparation.**—The industrial preparation of this acid is subsidiary to the manufacture of sulphate of soda, intended for the production of soda ash. It is produced by decomposing common salt by sulphuric acid.

$2NaCl$	+	H_2SO_4	=	Na_2SO_4	+	$2HCl$
Sodium chloride.		Sulphuric acid.		Sodium sulphate.		Hydrochloric acid.

The salt is introduced into capacious cast-iron cylinders, luted with clay, and then sulphuric acid is run on to it. The hydrochloric acid which escapes is dissolved in earthen carboys containing water. Commercial HCl marks 22° by Baumé's hydrometer.

Use.—The searching examinations which have been made into the action of this acid on fungi have shown that its use is not advisable,

because its action on plants is deadly. Bolley, in 1894, tried to use the anticryptogamic properties of hydrochloric acid against potato scab. The germs of this disease are killed, it is true, by steeping from five to twenty-four hours in a 2 per cent solution of this acid, but the eyes of the potato suffer so badly that this method cannot be advantageously used. Wuthrich, in a research published in 1892 on the action of metallic salts and acids on the spores of different fungi, proved that the amount of this acid required to prevent the germination of spores compared with that of sulphuric acid used is proportional to their chemical equivalents. Thus a solution of 0·0036 of HCl has the same anticryptogamic effect as a solution of 0·0049 per cent of H_2SO_4. A solution of HCl of 0·0036 per cent of sulphuric acid prevents germination of the conidia and zoospores of *Phytophthora infestans*, De By.; the conidia and the zoospores of *Peronospora viticola*, De By.; the spores of *Ustilago carbo*, Tul. But to prevent the germination of the uredospores of *Puccinia graminis*, Pers., acid of 0·036 per cent is required. Hydrochloric acid can replace sulphuric acid wherever the latter has given good results, if the plant be not unfortunately as sensitive as the spores of fungi.

Action of Chlorine and Hydrochloric Acid on Plants.—Hydrochloric acid and bleaching-powder factories discharge chlorine and hydrochloric acid vapours into the air. The injurious effect of this gas makes itself felt sometimes two miles from the factory, a radius within which it kill plants. This gas is even more poisonous than sulphurous acid itself; deciduous trees suffer as well as evergreens. The pathological condition ot the plant attacked is distinguished by the brown border which forms on the leaves; then they are covered with brown spots. The needles of spruce fir trees become yellow at the point, dry up, and drop off. The analysis of the dry substance of the diseased plant twenty-five minutes distant from these factories, according to König, Steffeck, and Heine, gave the following results:—

TABLE XV.—*Showing the Effect on the Chlorine Content of Forest Timber of Proximity to a Hydrochloric Acid Works.*

Tree.	*Condition.*	*Per cent Chlorine.*	*Increase in Chlorine Per cent.*
Oak	Healthy	0·081	
	Sickly	0·191	135·8
Beech . . .	Healthy	0·211	
	Sickly	0·311	71·14
Larch	Healthy	0·279	
	Sickly	0·767	174·91
Spruce . . .	Healthy	0·101	
	Sickly	0·132	30·69
Hazel . . .	Healthy	0·178	
	Sickly	0·516	189·88

These analyses show that the disease is produced by the absorption of chlorine and hydrochloric acid.

10. **Nitric Acid.—Preparation.**—The commercial acid is prepared by introducing into a cast-iron pan 330 kilogrammes (726 lb.) of nitrate of soda and 420 kilogrammes (964 lb.) of sulphuric acid of 62° Baumé; the lid is luted with clay and heated. The nitric acid vapours disengage through an earthen pipe, condense in big carboys, also of earthenware, placed one after the other, and each containing a little water. There are thus obtained 440 kilogrammes (968 lb.) of nitric acid of 36° Baumé.

Properties.—Nitric acid is a colourless liquid, sometimes yellow from the presence of nitrous acid. Its density is 1·52, its boiling-point is 86° C. It is very corrosive; in contact with organic matters it first produces nitrated compounds, then an oxidation which proceeds so far as destruction. It is quite as dangerous as sulphuric acid, and should be handled with many precautions.

Action of Nitric Acid on Plants.—The following are the results of the examination of nitric acids on plants: 0·05 gramme of this acid in a cubic metre of air produces poisonous effects on plants analogous to those produced by sulphurous acid; spots and brown borders on the leaves; yellow points on the needles of the conifers. The normal dose of nitric acid in the air is 0·00003 per cubic metre; it therefore requires a dose almost 2000 times stronger to produce pathological symptoms in the plant such as occur in the neighbourhood of factories which allow the vapour of these acids to escape.

Use.—Nitric acid is not only corrosive but poisonous to insects. This latter property is manifested, more especially, in organic compounds containing one or more nitro groups. Nitric acid, like sulphuric acid, has been recommended especially to combat insects in winter. Its action on fungi is especially injurious. Hitchcock and Carleton found that the uredospores of *Puccinia coronata*, Corda (crown rust of oats) are killed in twenty-four to twenty-six hours in nitric acid of 0·68 per cent, but an acid of 0·068 per cent has no action on these spores.

The spores of *Phytophthora* and *Peronospora*, according to present knowledge, are destroyed by an acid of about 0·05 per cent. Nitric acid is not used to combat fungoid parasites except *black rot*, although it has been tried against several other cryptogams.

Guignardia Bidwells, Viala et Ravaz (black rot).—Viala, the learned professor of Grignon, proposes to replace sulphuric acid in the winter treatment of the vine by nitric acid, which destroys the spores of this fungus. Against *insects* the first experiment dates as far back as 1872. Lemoine recommended for the treatment of the phylloxera the coating of the stems with a mixture consisting of 1 kilogramme of nitric acid of 60 per cent, 2 grammes of spirits of turpentine, and 4 grammes of chrome yellow, the whole diluted in 5 litres of water. Examined by the commission who investigated the chemical products proposed to combat this insect the above mixture was pronounced defective.

At the present time it is recognized that nitric acid is very injurious to grubs and may be used wherever these are not on the vegetative part of the plant. By this method the grubs of the *Tortrix Vitana* (pyralis of the vine) and the *Conchylis Ambignella*, Hubn (cochylis of the vine), which pass the winter in the fissures of the bark of the stem.

Fig. 6.—Decorticator.

Although Dufour's experiments, which could not destroy the grubs of the *cochylis* by steeping them for some seconds in 50 per cent nitric acid, do not speak in favour of the insecticide action of this acid, the results obtained in actual practice have been very favourable. Sourdon and Castel, as well as Debray, have recommended for the winter treatment of the vine the use of commercial nitric acid diluted with six times its weight of water. After having barked the vine by Sabaté's iron glove, the eyes, the runners, and the body of the stem are coated with nitric acid. The method may be applied in all weathers, and its efficacy is almost always absolute. Debray is of opinion that nitric acid may replace *ebouillantage*, "scalding," which is a complicated method, and often inapplicable. Like the latter, it frees the vine from all cryptogamic parasites, and from all insects which seek a refuge in winter in the corners of the bark. Barbut's observations which in-

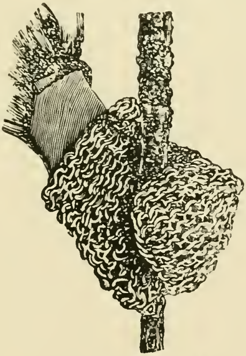

Fig. 7.—Sabaté's Glove.

duced him to affirm that 10 per cent nitric acid only kills 50 per cent of *pyralis* and 40 per cent of *cochylis*, that the chrysales of *pyralis* can stand steeping in that acid for several hours without injury, and that treatment by nitric acid retards, moreover, the growth of the vine, in no way diminishes the good results obtained in actual practice, and the success of the winter treatment of the vine by nitric acid.

CHAPTER V.

PHOSPHORUS — PHOSPHORETTED HYDROGEN — ARSENIURETTED HYDROGEN—ARSENIOUS SULPHIDE—ARSENIOUS ACID—WHITE ARSENIC—ARSENIC ACID—BORIC ACID.

11. **Phosphorus.—Preparation.**—Phosphorus does not occur in nature in the free state, but as phosphoric acid combined with various metallic oxides, lime, magnesia, soda, etc. In the industrial manufacture bones form the raw material.

Properties.—Phosphorus insoluble in water and alcohol dissolves in carbon disulphide. It is combustible. It oxidizes in the air at the ordinary temperature but does not ignite below 60° C. (140° F.). It melts at 44° C. (111·2° F.). It is preserved under water. Phosphorus is a violent poison which, when absorbed even in very small doses, induces vomiting and epigastric pains. It may act if it continue to be absorbed on the nervous system, which it depresses, and by paralysing the heart's action, it rapidly causes death. The intensity of the action of phosphorus depends on the form under which it is ingested; dissolved in oil, for example, it is much more poisonous than when in solution in other solvents, because in this form it is precipitated less easily in the aqueous juices of the stomach.

Use.—Phosphorus is as violent a poison for mammals as for insects. It is used everywhere where pastes can be used to destroy noxious animals. To prepare these pastes 50 oz. of boiling water are run into a porcelain mortar, then 2 oz. of phosphorus which soon melt therein; 40 oz. of flour are then added whilst stirring with a wooden spatula. When the mixture is almost cold 40 oz. of molten tallow still tepid are run in and 20 oz. of sugar. This paste may be used indifferently against rodents and certain injurious insects. The *Murides*, such as *Arvicola* (field mice), *Mus musculus* (domestic mouse), *Mus agrarius* (field mouse), *Mus ratus* (ordinary rat), *Mus decumanus* (Surmulot rat), are destroyed by the phosphorus pastes, the preparation of which is given above. Mohr adds a little glycerine which preserves them longer in the air. With this poisonous paste slices of toasted bread are coated which the rodents eat without suspicion. According to Crampe it suffices to prepare a paste of boiled flour which is cooled to 43° C. (109·4° F.) before mixing in the phosphorus; pieces of straw are then dipped into the paste and laid in the burrow or in the run of the rodents. The latter in trying to remove them or in walking on them get daubed with pieces of paste on the hair, and are poisoned by licking themselves.

Amongst the insects killed by phosphorus are: *Periplaneta orientalis* (cockroach). This insect does great damage in hothouses by

gnawing orchid roots. Paste pills made from honey and phosphorus and laid on the pot of the plant attacked rapidly destroy the insect.

Gryllotalpa vulgaris (mole-cricket).—Elias Hugo destroys it by laying poisoned pastes of maize, starch, water, and phosphorus in the burrows and stopping up the orifices. The mole-crickets disappear in twenty-four hours.

Formica (ants).—To poison ants Debray introduces phosphorus paste made from molasses and phosphorus. The orifices of the nest are then stopped.

12. **Phosphoretted Hydrogen**, PH_3.—**Preparation.**—(1) By the action of phosphorus on caustic alkalies or the hydroxides of the alkaline earths in presence of water and under the influence of heat. (2) By decomposition of calcium phosphide by water alone or by hydrochloric acid.

Properties.—Phosphoretted hydrogen is a colourless gas with a strong garlic smell, inflaming at 60° C. (140° F.). It is poisonous, and acts especially by depriving the hæmoglobin of the blood of the oxygen fixed therein.

Use.—Phosphoretted hydrogen is recommended for combating the phylloxera. Mouillefert showed this gas to be five times more poisonous than prussic acid. An atmosphere containing 0·5 per cent of phosphoretted hydrogen is very injurious to the phylloxeras, but the latter are not destroyed until after they have been fourteen hours in an atmosphere containing 1 per cent of this gas. Experiments on the large scale have given variable results; those of Mouillefert, a negative one; those of Rosler, a perfect one. The former wrought thus: 20 grammes (310 grains) of phosphide were laid in three holes of 50-60 centimetres (20-24 inches) in depth, at equal distances round a stock, and then closed. The moisture and carbonic acid in the soil decomposed the calcium phosphide. Rosler, on the other hand, recommends the digging of holes around the stock, and to lay therein several layers of quicklime, on which a small piece of phosphorus is placed. The holes, filled up, are covered with water and then stopped with clay. Rosler recommends this treatment as efficacious, and without any injurious effect on the vine treated; it is done in the spring. Mouillefert ascribes the bad result of his experiments to the rapid oxidation which goes on in the soil, and to the feeble diffusion of phosphoretted hydrogen, which is less rapid than carbon disulphide.

13. **Arseniuretted Hydrogen**, AsH_3.—**Preparation.**—By decomposing certain arsenides, such as those of zinc and tin by dilute sulphuric acid. Zinc arsenide is obtained by fusing 100 parts of zinc with 75 parts of arsenic in an earthenware retort.

$$As_2Zn_3 + 3H_2SO_4 = 2AsH_3 + 3ZnSO_4.$$

Properties.—Arseniuretted hydrogen is a colourless, inflammable gas with a strong garlic odour. It is exceedingly poisonous and must not be breathed even when it is diluted with much air.

Use.—In America it has been tried to destroy the kermes of fruit trees. Coquillet covered the trees with a tent, under which he caused AsH_3 to be disengaged, but the results were not so satisfactory as

those obtained by prussic acid in similar conditions. This gas is so poisonous that it can never be used in actual practice.

14. **Arsenious Sulphide,** As_2S_3 (yellow orpiment).—Loarer, in 1872, sprayed vines attacked by the phylloxera with a bouillie containing 0·1 per cent of this product, but without success.

15. **Arsenious Acid,** As_2O_3.—Arsenious acid, or arsenic, is obtained, commercially, by roasting arseniferous minerals, the arsenides, and sulpharsenides of nickel, cobalt, and iron, in capacious muffles, of refractory material, round which the flame from the fire circulates.

$$2FeAsS + 3O = 2FeS + As_2O_3.$$

The arsenious anhydride given off is led into cold, superimposed chambers, where it condenses as a white crystalline powder. It is removed by raking it out and purified by distilling it in wrought-iron vessels.

Properties.—White arsenic is a white or colourless, inodorous solid; recently fused, it forms a vitreous, transparent, amorphous mass. White arsenic only dissolves at 13° C. in water, in the ratio of 1·2-1·3 per cent, whilst the vitreous acid dissolves in the ratio of 4 per cent. Its taste is at first faint, then bitter and nauseous. Arsenious acid is a violent poison for all animals, and in a dose of 1 decigramme, say $1\frac{1}{2}$ grains, kills man. It is a violent escharotic of the mucous membrane, and of all the tissues in general, which it inflames, and rapidly destroys. Absorbed by the digestive channels, it gives rise to gastro-intestinal symptoms, which are often followed by paralysis. In very small doses it is a powerful stimulant, which encourages growth. This property causes it to be much used in medicine. Arsenic is as poisonous to plants as to animals. It burns the leaves. Arsenites soluble in water are the more active the greater their solubility; those which are insoluble in water consequently have no injurious action on plants.

Herbaceous plants die when they are watered with a 0·5 per cent solution. Deciduous trees are also very sensitive to the action of arsenic. To destroy certain insects, a solution of 200 grammes in 100 litres (2 lb. per 100 gallons) were tried, but even in that proportion the arsenic is still too prejudicial to the leaves.

TABLE XVI.—*Showing Sensitiveness of Leaves of Various Fruit Trees to Solutions of Arsenious Acid of Various Strengths.*

Name of Tree.	*Grammes As_2O_3 per 100 litres.*[1]	*Effect on Leaves.*	*Name of Tree.*	*Grammes As_2O_3 per 100 litres.*[1]	*Effect on Leaves.*
Apple . .	30	Browned	Negundo Aceroids	30	Burnt
Plum . .	15	,,	Gleditschia Triacanthus . .	24	,,
Plum . .	10	Attacked	Poplar . .	15	,,
Vine . .	48	Burnt	Raspberry . .	34	,,

[1] Parts by weight in 100,000 parts by volume.

Gillette found that in a much weaker dose arsenic is still injurious, and that, in this respect, different plants are not equally sensitive.

These doses being often insufficient to kill the insects, arsenic solutions were completely abandoned, and replaced by neutral bouillies, in which the arsenic is generally in the insoluble condition, and thus in a form which does not injure the plant. Arsenious acid has also a very decided action on the spores of fungi. This action was long known and utilized to disinfect cereal grains, when, in 1856, Boussingault recommended the use of arsenite of soda for the disinfection of grain. This process was, in his opinion, the best for freeing farm crops from smut, bunt, rust, caries and ergot; it, moreover, had the advantage of protecting the grain from the ravages of injurious animals after sowing.

Use.—The French Ordinance of 1846, Article 10, "The sale and use ot arsenic and its compounds are interdicted for the pickling of grain, the embalming of corpses, and the destruction of insects," has prevented its use in France, but in other countries the valuable properties of this product have earned for it numerous applications. The first trials were made in America in 1867, when Markham used arsenic to combat an insect very deadly to the potato, the *Leptinotarsa decemlineata* or Doryphor of Colorado (the Colorado beetle). The use of arsenic became general in 1871, but especially in the form of neutral bouillies, with an emerald green or Scheel's green basis, London purple or arsenite of lime, or in admixture with different anti-cryptogamic salts. Gillette also recommended, in the form of powder, mixed with much flour. In this form it has been recognized as less injurious to the leaves than in solution, and is thus recommended every time that spraying cannot be adopted. To-day white arsenic is hardly used except to poison the pastes for the following insects: *Agriotes lineatus* or *Elater segetis*, L. (wire worm), injurious to cereals; *Agriotes* or *Elater sputator*, L. (spitting click beetle), injurious to lettuce; *Agriotes* or *Elater obscurus*, L. (dusky click beetle), injurious to carrots. It is very difficult to get at the larvæ, as they live hidden. Comstock recommends to destroy them by pastes poisoned by arsenic. For this purpose small bundles of lucerne are prepared towards July, of which the larvæ are very fond; they are dipped in a 1 per cent solution of arsenious acid, they are then placed in the infected fields, taking care to cover them with flower-pots so as to keep the lucerne moist which should always appear as if fresh cut.

Gryllotalpa vulgaris (mole-cricket).—To poison this insect Lehmann spreads in the spots frequented by it preparations made thus: thyme, sweet marjoram, sweet basil, with ground arsenic, earth, or sand. The mole-crickets, very fond of these seeds, come to eat them and are poisoned.

Acrydium migratorium (Criquet migrateur); *Acrydium peregrinum* (Criquet pelerin).—Chemicals are only rarely used to combat these locusts; battues and Cypriot's apparatus are preferred. However, Coquillot recommends the use of poisonous preparations. One lb. of sugar is dissolved in enough water to form a syrup, there is then stirred in 1 lb. of arsenic and 6 lb. of bran. This paste is divided into

pieces the size of a nut and then laid in front of the line of invasion of the locusts at the distance of a yard and in several parallel rows.

Agrotis segetum, W. V. (the common dart moth); *Agrotis exclamationis* (the heart and dart moth).—Coquillot recommends bunches of lucerne, steeped in a 1 per cent solution of arsenic, or the preparation already prescribed to destroy locusts. The preparation is placed round the stocks of the vines; the grub, seeking its shelter in the morning on the vine, grazes the arsenic of the preparation and is poisoned by contact, for this product kills the insects that touch it as well as those that absorb it through the digestive channels.

Kermes.—It is asserted that these parasites do not resist a 1 to 3 per cent solution of arsenic.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—The effects of arsenic on this insect were examined by Cornu, Mouillefert, and Heckel. Arsenious acid was proposed like other substances at the moment of the phylloxeric invasion. The insecticide properties of this product being known, it was hoped to be able to destroy this formidable insect by watering the soil round the stocks with a dilute solution of this poison. The phylloxera infected vines, after having been stripped within a radius of 10 inches round the root, were each treated with 25 grammes of arsenic dissolved in 10 litres of water. [Dissolve $2\frac{1}{2}$ lb. arsenic in 100 gallons water and give each vine $2\frac{1}{5}$ gallons.] The adult phylloxera were found dead, but the young ones were quite robust. As soon as the diffusive action of the soil had rendered the arsenic powerless, the phylloxera multiplied once more. Other trials showed that this dose is quite insufficient to destroy the phylloxera of the vine. Vines so infected placed in pots containing 4 litres of earth received 1·5 gramme (23 grains) of arsenic in 100 grammes ($3\frac{1}{2}$ oz.) of water. This, though a considerable dose, did not free the vine from its parasites. It corresponded to 375 grammes of arsenic per cubic metre of soil, and is not withstood by the vine, which can stand a $\frac{1}{4}$ per cent solution, but a $\frac{1}{3}$ per cent affects it. Arsenic has not therefore been judged capable of being taken into account for the destruction of the phylloxera.

Rodents (mice, rats, field mice, moles).—Arsenic is the poison most often used to destroy rats. The success of the famous poison "Rough on Rats" is due to the arsenic it contains.

There are different methods of making these preparations: (1) Boil wheat in water saturated with arsenic; boiling must not be too prolonged, as the grains must remain hard. Place some of the grains, after wiping them, in each hole. To destroy the field mouse it is better to operate in winter, when the animal is famished. (2) Mix 100 grammes of arsenic ($3\frac{1}{2}$ oz.) with 1 kilogramme of tallow (say $2\frac{1}{4}$ lb.), 4 grammes (say $\frac{1}{8}$ oz.) anise, and 10 grammes (say $\frac{1}{3}$ oz.) lampblack. The paste is spread on very thin slices of toasted bread. (3) Mix $4\frac{1}{2}$ oz. flour with 1 oz. of arsenic and place a little of the powder in a drain pipe, about $1\frac{1}{8}$ inch in diameter; place this pipe near the mole holes. This method keeps the poison beyond the reach of game and dogs. These pipes can also be used for poisoned grain. (4) Cut a celery root in two parts, make a cavity in each piece, and fill it with arsenic,

then stick the two pieces together by a glue without smell. Thus, after removing the point of one of these roots a conical hole is made in it, arsenic placed in the opening so made, and closed by the piece removed, which forms a natural plug. Place the celery so prepared in the nests. Complete success will be obtained if precaution be taken to accustom the rodents to this preparation by giving them first non-poisoned celery.

16. Arsenic Acid, As_2O_5.—**Preparation.**—By oxidizing arsenious acid by nitric acid.

Properties.—Arsenic anhydride is a white solid. It dissolves slowly in water. It is a more violent and more rapid poison than arsenious acid.

Use.—Arsenic acid has been proposed for the disinfection of seed-corn. A powder is prepared with 9 parts of lime and 1 of arsenic acid, with which the corn kept moist is sprinkled in the proportion of $3\frac{1}{3}$ lb. per $2\frac{3}{4}$ bushels of grain. After twenty-four hours the seeds were dried and sown.

17. Boric Acid, B_2O_3.—**Occurrence.**—Occurs in nature sometimes free, sometimes combined with bases.

Preparation.—By decomposing borax (sodium diborate) by hydrochloric acid. Borax is dissolved in four times its weight of water and hydrochloric acid added to a decidedly acid reaction. Boric acid crystallises out as shining scales on cooling, is drained and washed with cold water.

Properties.—Boric acid occurs as shining scales, but little soluble in water; 4 per cent at 20° C. It is a weak antiseptic. To preserve meat for three weeks it must be steeped in a 4 per cent solution.

Use.—Kuhn has examined its antiseptic power on bacteria. A 1 per cent solution does not stop their growth. A 2 per cent solution stops the growth of bacteria. Even a 4 per cent solution does not kill them. The alcoholic fermentation of saccharine solutions containing 2 per cent boric acid is not completely arrested (Schwartz). Constantin and Dufour tried without success a 2 per cent boric acid solution to kill the mole disease of the mushroom (*Mycogone perniciosa*).

CHAPTER VI.

AMMONIA—AMMONIUM SULPHIDE—AMMONIUM SULPHOCYANIDE—AMMONIUM SULPHATE—AMMONIUM CARBONATE—SODIUM HYPOSULPHITE—SODIUM SULPHATE—SODIUM CHLORIDE (COMMON SALT)—SODIUM NITRATE (CHILI SALTPETRE)—ARSENITE OF SODA—BORAX—SODIUM CARBONATE.

18. Ammonia, NH_3.—**Preparation.**—By distilling ammonical gas liquor or fermented urine with lime.

Properties.—Ammonia is a colourless gas with a pungent smell, which irritates the mucous membranes, and an acrid taste. Aqueous solutions are met with in commerce, as liquor ammoniac, containing about 30 per cent of ammonia gas. Such solutions rapidly alter in the air by the evaporation of the dissolved gas. Owing to its causticity ammonia is employed in medicine as a rubefacient, or to induce vesication. Ammonia is one of the nutritive substances of the plant, and its presence in the air greatly stimulates the growth of the latter. Normally the air does not contain more than 0·056 milligramme of ammonia per cubic metre, but this dose varies much. The amount varies according to the altitude: at 395 metres, 0·9 to 2·76 milligrammes; at 1446 metres, 3·18 milligrammes; and at 1884 metres, 5·5 milligrammes. The dose injurious to plants is about 1000 times greater than the normal dose. Some plants are more sensitive than others (Meyer). Whilst 243 milligrammes of ammonia per cubic metre of air had no bad effect on oaks, even if they remained an hour in that atmosphere, 70-86 milligrammes caused a pathological condition on plum-trees and cherry-trees. A dose of 32-36 milligrammes of ammonia per cubic metre has no caustic action on the most sensitive of vegetables. The symptoms of burning by ammonia are the following: The leaves of the oak blacken; those of cherry-trees and plum-trees become brown; haricots blacken; and cereals lose their colour and become quite pale. Young buds are much more sensitive than old leaves. A 0·003-0·005 per cent solution has no action on the protoplasma of maize, haricots, tomatoes, and strawberry plants; more concentrated solutions increase the movements of the protoplasma.

The seeds of *Phaseolus multiflora* germinate in nine days in an atmosphere containing 0·003-0·004 per cent of ammonia; likewise the seeds of *Vicia faba*, when the ambient air contains 0·0031 per cent of this gas. In an atmosphere containing 0·005 per cent of ammonia leguminous seeds cannot germinate, and a 0·0083 per cent solution exercises an unfavourable action on young maize, owing to its diminished growth.

Use.—The causticity of ammonia being known, it is evident that

care must be taken not to bring it in contact with plants. Ammonia enters into the composition of certain anticryptogamic bouillies, and chiefly *eau celeste* used to kill mildew. The good effects of this preparation are indisputable; but they can only be obtained by working with an absolutely neutral solution, a point which does not receive in the majority of cases the serious supervision which it requires. It follows that mishaps occur, which should not be produced with a substance possessing all the properties that can be desired. Pure ammonia has few applications in agriculture. However, gas liquor, which is cheap, is in general use. These ammoniacal liquors kill mosses in meadows and impart fresh vigour to grain crops. But in the condition in which they are bought these liquors are too concentrated, and might kill graminaceous crops. They must be reduced by an equal quantity of ordinary water, and only 4000 litres of this mixture spread per hectare (352 gallons per acre) (Noffray). The following diseases are combated by ammoniacal treatment:—

Heterodera Schachtii, Schmidt (nematode of the beet).—Willot has published very satisfactory results which he has obtained by the use of ammoniacal liquors. The infested beet fields, producing, on an average, 4 tons of beets per hectare, say 1·6 ton per acre, yielded 37 tons per hectare, say 14·4 tons per acre. In Willot's *brevet* the nematodes succumb to the alkaline action of gas liquors, provided they contain 5 per cent of ammonia. The results obtained by others have not been so favourable. Hollrung, Strohmer, and Stift have, in fact, energetically combated the efficacy of this treatment, their experiments having given no satisfactory result. Hollrung even remarks that beet seed was not capable of springing up in a soil treated with ammoniacal liquor. To avoid this drawback Willot follows up his treatment by spraying with ordinary water. Be that as it may, this treatment cannot be so efficacious as that due to Aimé Girard, which consists in using a strong dose of carbon disulphide, and which ought always to be preferred.

Jassus sexnotatus (grain grasshopper). — Steglich recommends ammoniacal liquor of gasworks, in which 2 per cent of soft soap is dissolved, the whole diluted with an equal bulk of water, to get rid of this pest. Sorauer eulogizes the good effects of this treatment, and recommends spraying with a solution made in the ratio of 30 lb. of soft soap and 3 gallons of commercial ammonia in 100 gallons of water. Muhlberg's experiments with gaseous ammonia and ammoniacal liquors to destroy the *Schizoneura lanigera* (woolly aphis); Coquillet's to destroy kermes; Voiret and Gervais's, then Mouillefert's, to combat phylloxera of the vine, have given negative results.

19. Ammonium Sulphide, $(NH_4)_2S$. — **Preparation.** — Ammonia forms, when combined with a semi-molecule of sulphuretted hydrogen, hydrosulphide of ammonia or ammonium sulphide.

Properties.—Ammonium sulphide is crystalline, colourless, and very soluble in water.

Use.—*Dematophora necatrix*, Hartig (root rot).—Dufour tried to replace carbon disulphide by this substance, but the results obtained were not perceptible.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—Mouillefert found that the phylloxera dies in twenty-four hours in an atmosphere containing 1 per cent of ammonium sulphide. Used in small dose on a vine in pot where the whole soil could be impregnated with this substance, the result was satisfactory, but on the large scale diffusion is not so perfect, and the result was always incomplete in spite of the toxicity of the two gases which form this salt, ammonia and hydrogen sulphide. Mouillefert experimented thus: The stocks, stripped to 30-35 centimetres (12-14 inches), were watered with 400 cubic centimetres of the liquid sulphide, then with 10 litres of water; after the liquid was absorbed the earth was put back round the stock. On roots 50-60 centimetres (20-24 inches) deep the effect was, so to speak, *nil*, and it was even observed that the phylloxeras had not been entirely destroyed on the upper roots. According to Couvy and Rohart, this bad result was due to the ammonium sulphide rapidly decomposing in the soil to form inert combinations such as ammonium sulphate.

Conchylis Ambignella, Hubn. (cochylis of the vine).—Dufour recommends against the grub of this butterfly a solution of 3 per cent of ammonium sulphide and 3 per cent of soft soap, which he regards as being more efficacious than carbon disulphide.

20. Ammonium Sulphocyanide, NH_4CNS. — **Preparation.** — By heating potassium sulphocyanide with ammonium chloride.

Properties.—A crystalline salt soluble in water. Its action on fungi seems less toxic than that of potassium sulphocyanide. A 0·1 per cent solution of this salt has no bad effect on the development of the uredospores of *Puccinia coronata*, Cord., even after an immersion of twenty-seven hours. Schumann found that by watering meadows with a solution of this salt, at the rate of 200 kilogrammes per hectare (176 lb. per acre), the aerial part of the herbage is killed and growth much weakened.

21. Ammonium Sulphate $(NH_4)_2SO_4$.—Sulphate of ammonia is manufactured commercially by distilling the ammoniacal liquor of gasworks and putrid urine. The volatile portions are collected in dilute sulphuric acid, the liquors obtained are concentrated in lead tanks, where the sulphate of ammonia crystallizes in prisms.

Properties.—Ammonium sulphate forms anhydrous permanent prisms. It dissolves in 2 parts of cold and 1 of boiling water.

Uses.—As an ammoniacal manure.

Heliophobus popularis.—Amongst the insecticides used to destroy the grub of this Lepidoptera, which causes such damage to meadows, Marchand found that only a 10 per cent solution of ammonium sulphate in purin gave appreciable results.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—According to Rosler's experiments on the phylloxera, with the most diverse substances, ammonia had on these plant-lice as energetic an effect as carbon disulphide and sulphuretted hydrogen, but that it had not such a poisonous effect on the plant as the two latter gases. To generate the ammonia gas in the zone invaded by the louse, Rosler recommends to pierce holes with the pal round the vine, and to fill them either

with alternate layers of newly slaked lime and ammonium sulphate, and spray afterwards with water, or with lime alone, and then spray with a solution of sulphate of ammonia. The holes are then plugged with clay or wooden plugs. The ammonia gas generated by the mixture of these substances reaches the phylloxera, and infallibly kills it.

Mouillefert determined that if the phylloxera be sensitive to ammonia it is difficult on the large scale to destroy it with ammoniacal liquor. A phylloxera-infested root dipped for three minutes in ordinary ammonia, or exposed for an hour to the vapours of 5 cubic centimetres of this substance in a 2-litre bottle was freed from all its parasites, but these experiments repeated on a phylloxera-infested vine in pot gave no good results. For that purpose 10 cubic centimetres of ammonia were poured into two holes which were immediately plugged. The beards of the root in existence before the experiment were destroyed and the swellings on the large roots still bore numerous parasites. Ammoniacal liquor, according to this experiment, is not, therefore, capable of destroying the phylloxera without imparting grave injuries to the plant. In fact, 20 cubic centimetres of this liquor employed in the same conditions on a healthy vine burnt the leaves, and 40 centimetres killed them. Ammonia used as vapour does not appear to have the injurious action of ammoniacal liquor on plants. Ammonium sulphate used according to Rosler's indications, may thus have as great an action on the phylloxeras as it has on the vine, by imparting new vigour to it in virtue of its nutritive properties.

22. Ammonium Carbonate $(NH_4)_2CO_3$.—**Preparation.**—By heating in a cast-iron retort an intimate mixture of equal weights of ammonium sulphate and chalk. The volatile salt is condensed in a receiver.

Properties.—Ammonium carbonate is a transparent crystalline salt with a caustic taste and exhaling ammoniacal odour. In contact with air it loses a part of its ammonia and is converted into a more stable bi-carbonate. Solutions of ammonium carbonate are completely dissociated into ammonia and carbonic acid when heated.

Use.—Hitchcock and Carleton have observed that a 1 per cent solution of ammonium carbonate stopped the growth of the uredospores of *Puccinia coronata*, Corda, after seventeen hours' action.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—The effects of ammoniacal manure, such as ammonium carbonate, which stable manure contains in notable quantities, have always been successful on phylloxera-infested vines. Rosler ascribes this to the ready dissociation of this salt into ammonia—especially poisonous to the phylloxera—and carbonic acid. So as to render it still more active, he advises the manure containing the ammonium carbonate to be spread in the spring, because the young generations of phylloxera are much more sensitive than the adults. Mouillefert is of another opinion. According to his experiments a solution at the rate of 2 lb. of this salt in 25 gallons of water with which he watered a phylloxera-infested vine was incapable of killing the phylloxeras. He concluded that ammoniacal salts only acted as fortifiers of the plant.

23. Hyposulphite of Soda, $Na_2S_2O_35H_2O$.—**Preparation.**—Sulphites boiled in presence of sulphur are converted into hyposulphites. To accomplish this, a solution of sulphite of soda is boiled with excess of sulphur until saturated; it is filtered and cooled. Large crystals of sodium hyposulphite form. Commercially this salt is prepared by the action of sulphurous acid on calcium sulphide (alkali waste). The hyposulphite of lime formed is converted by sodium sulphate into sulphate of lime and hyposulphite of soda.

Properties.—Hyposulphite of soda is a colourless salt, permanent in air, with a bitter taste and very soluble in water. It is less stable in solution than in crystals; even in the absence of air it is decomposed into sulphite of soda and free sulphur which is deposited. In contact with acids the hyposulphite is decomposed into fine sulphur and sulphurous acid:—

$$Na_2S_2O_3 + 2HCl = 2NaCl + H_2O + SO_2 + S.$$

Heated out of contact with air it splits up into sodium pentasulphide and sodium sulphate. The use of sodium sulphite has been recommended in medicine, especially against itch. Rubbing with a solution of hyposulphite of soda is followed by washing with dilute hydrochloric acid. The sulphurous acid disengaged and the sulphur precipitated in the pores of the skin make the sulphite a very efficacious agent in the destruction of this *acarus*.

Action on Plants.—The hyposulphite acts like the sulphite of soda and sulphurous acid. Absorbed by the leaves of plants it is there converted into sulphuric acid and burns the leaves. The experiments therefore to replace sulphur by this salt which, so to speak, contains dissolved sulphur have been abortive because it burns the leaves, and the more so the greater the heat. Kaserer observes that it suffices to use a solution of hyposulphite rendered alkaline by milk of lime to obviate this drawback.

Action on Fungi.—Sulphur in hyposulphite of soda preserves its anticryptogamic properties and imparts them to it. Like sulphur hyposulphite of soda has been recognized as capable of killing all fungi, the mycelium of which crawls on the surface of the plant.

Puccinia Coronata, Cord. (coronated rust of oats).—Hitchcock and Carleton examined the action of solutions of hyposulphite on the uredospores of this rust and found that a 1 per cent solution has no injurious action thereon, but it exerts a retarding action on the germination and a diminution thereof on the seed steeped therein for twenty-six hours.

Uncinula Americana, How. (oidium of the vine).—Pauly examined the action on oidium of a double hyposulphite of soda and silver. After a microscopical examination he observed the great alteration undergone by the mycelium in contact with a solution containing 0·1 to 0·2 per cent of this salt, and concluded that the use of this salt as a curative agent would give good results. However this salt, sold under the name of "Puknos," has been abandoned in the treatment of the vine because it burned the leaves especially during great heat, and that much more so than the sublimed sulphur which it was to replace.

By adding 300 grammes of hyposulphite of soda to a 1·5 per cent bouillie bordelaise, Kaserer obtained by three sprayings in a year complete success in treating oidium without the treatment being followed by the burning of the leaves. Solutions of hyposulphite to which milk of lime was added have been found more energetic than sulphur.

Sphærotheca pannosa (mildew of the rose).—Vesque proposes hyposulphite of soda to destroy mildew of the rose.

Guignardia Bidwelli, Viala et Ravay (black rot of vine).—Pauly remarks that the double salt, hyposulphite of soda and silver, is capable of arresting the progress of the black rot in full evolution; used in a 1 per cent solution its effect on the spores and the mycelium is most conclusive. This product has therefore been used to destroy this disease by making three sprayings per annum on the attacked vines. This treatment, which burned the leaves, has not been the success anticipated.

Crouzel's anticryptogamic which contains both calcium polysulphide and a little naphthaline, and 0·2 per cent of hyposulphite of soda is recommended to combat the cryptogamic diseases of the vine, and particularly the black rot and the oidium. Spraying should alternate with five or six days' interval with those made from copper preparations.

Dematophora necatrix, Hartig (white root rot).—Dufour used this salt without appreciable result.

24. Sodium Sulphate, Na_2SO_4.—**Occurrence.**—In Spain vast mines of sodium sulphate have been exploited for some years.

Preparation.—By decomposing sodium chloride by sulphuric acid:—

$$2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl.$$

Properties.—Crystallized sodium sulphate or Glauber's salt contains 10 molecules of water of crystallization. Heated, these crystals melt in their water of crystallization and lose it by igneous fusion. Anhydrous sodium sulphate, a white amorphous powder, is formed. Sodium sulphate reaches its maximum solubility in water at 33° C. It is a neutral body which has no action on plants except when highly concentrated. Seeds, however, do not stand without injury prolonged immersion in a bath of 2 per cent of sulphate of soda.

Use.—Mathieu de Dombasle discovered the injurious action of this salt on the spores of *smut* and *bunt*, and proposed it to replace common salt then in use to disinfect grain by sodium sulphate. The process in use up to then had many drawbacks. It consisted in macerating the grain in a mixture of lime and common salt for twenty-four hours, and only gave incomplete results. The use of the "Absolute Preservative of Mathieu de Dombasle" was a real progress from all points of view; it shortened the long immersion and gave a better result without injuring the grain treated. *Process.*—Dissolve 8 kilogrammes (17·6 lb.) of sodium sulphate in 100 litres (22 gallons) of water. Spread on the water-tight floor (of a ground floor) 1 hectolitre ($2\frac{3}{4}$ bushels) of the grain to be disinfected and water the

heap with this solution, stirring with the shovel until all the grains are well moistened. Then spread 2 kilogrammes (4·4 lb.) of lime recently slaked over the moistened grain, and stir the heap until all the grains are covered with a layer of lime. Hequet d'Herval declares that the success of this treatment is complete, and Loverdo regards this process as that which gives the best result, after Kuhn's blue vitriol disinfection process. Sulphate of soda is, moreover, less injurious to the grain than blue vitriol. Comes has slightly modified this treatment and advises that the spraying of the heap of grain be replaced by immersion in a solution of sulphate of soda. It suffices to immerse the seeds in a concentrated solution of sulphate of soda so that they are completely covered, then add milk of lime and stir for two hours, then spread the grain out to dry. G. Arieti estimates that sulphate of soda has a more injurious action on the spores of *Tilletia* (bunt) than sulphate of potash. He advises not to exceed a 2 per cent solution for the sake of the vitality of the grain, this quantity being quite sufficient to fulfil the object of sulphating (pickling).

25. Sodium Chloride (Common Salt), NaCl.—**Occurrence.**—Common salt is found crystallized in thick beds in certain countries. It also occurs in solution in sea-water and certain springs. The mines of rock salt of Cordoña (Spain), those of Wieliczka and of Bochnia in Poland, contain large quantities, and the purity of the product is so great that it suffices to pulverize the salt of these mines to impart to it a commercial form. A large amount of the salt used in commerce is obtained by the evaporation of sea-water. This operation is conducted on the horizontal surface of a clay soil. To facilitate the feeding of these basins they are placed below sea-level and form "Salines". Those of the Mediterranean extend from Hyères as far as Port Vendres. The evaporation of the sea-water is generally conducted in basins in which are deposited, until sufficiently concentrated, the different salts less soluble than common salt likewise found in solution in that water. Finally, it is run in layers of 5 centimetres into the smallest basins called "tables salants" (salt table), in which the salt crystallizes. The mother liquors are run off and the salt is lifted out by special flat shovels.

Properties.—Salt is met with as anhydrous crystals. The degree of solubility of the salt in water varies little, whatever be the temperature; 100 grammes of water at 18° C. dissolve 36 grammes of salt, and at 100° C. 40 grammes. Its use is necessary in the nutrition of the animal; administered in too high a dose, it cannot be eliminated by the skin, the kidneys, and the intestines, and remaining accumulated in the blood it may coagulate the albumen.

Rôle of Common Salt.—According to Sachs, Peligot, and Fraisse, sodium chloride or its elements, with few exceptions, are present in almost all plants. A feeble dose of common salt may thus act as a manure for plants, but a strong dose may be so injurious as to kill them. Braconnot, Schubler, and Meyer have shown that if the quantity of salt used exceeds a certain dose, it stops germination of the seed and the growth of plants. Dieterich proved that big doses of salt completely paralyse the first phases of plant life, and prevent the

development of the plant. But all plants and all seeds do not stand the action of salt to the same extent. As a result of some laboratory experiments, it is recognized that barley stands stronger doses of salt than tares, and oleaginous seeds resist salt better than other seeds.

Rôle of Common Salt as Manure.—To a greater extent than potassium the sodium necessary to the plant exists in all soils in sufficient quantity. Practice has, however, shown that the application of common salt to a soil rich in sodium is always followed by good results, provided always that a certain dose is not exceeded. In these conditions it is evident that it cannot act as (plant) food, and its rôle must be regarded from another point of view, and possibly the following. According to Braconnot, one of the first effects of salt added to a soil is to keep it moist. This property, which the salt owes to its affinity for water, is in a high degree favourable to the transport of the elements assimilated in the plant. Liebig, Voelcker, Malaguti, and Peligot agree in attributing to common salt the rôle of a solvent of phosphate of lime. Liebig in fact found that a solution of 1 kilogramme (2·2 lb.) of common salt in 500 litres (110 gallons) of water dissolves 15 grammes, say $\frac{1}{2}$ oz., of phosphate of lime. According to Boussingault, common salt decomposes carbonate of lime into calcium chloride and carbonate of soda (this action has been disputed by Kuhlmann, Isidore Pierre, and Peligot); the latter product would be absorbed by the plant, or would act in the soil on the organic matter to hasten its oxidation and contribute to the formation of nitrate of soda. The good effects of salt may be confirmed by spreading a small quantity on the land. In big doses it is, on the contrary, antiseptic and prevents the putrefaction of organic matter in the soil, and consequently the formation of nitrates. The nitrification of organic matter goes on slowly in cold weather; salt, therefore, has more action in southern countries than in northern countries (Kuhlmann). For the action of salt on arable land to be complete heat and moisture must be intermittent. In two dry years like 1846 and 1865 salt may be injurious because it then acts as a caustic, and corrodes the plant (Fraisse). Plants on the sea-coast are watered naturally by the salt water of the sea. There, where the desiccating action of the wind cannot wither up the plants behind the walls, the hedges, or the ramparts formed by forests, vegetation becomes luxuriant. It is otherwise quite on the seashore, the excess of salt, especially magnesium chloride, being as injurious to plants as the drying wind. Barren zones are thus to be found along the shore, according to whether the wind blows more or less frequently from the sea and according to the dryness of the year. The remarkable fertility of the "polders" of Holland is attributed to the temporary submersion of certain land a hundred years ago. In Camargue the soil is highly fertile, but the young blades of cereals must be protected by a layer of reeds, so as to prevent too great drying. The experiments of Lecocq have shown that it requires 150-200 kilogrammes (330-440 lb.) of common salt per hectare, say 132-176 lb. per acre, as a manure for lucerne, 250-300 kilogrammes (550-660 lb., say 220-264 lb. per acre) for flax and wheat, and 264 lb. per acre for barley. Kuhlmann,

Dubreuil, Fauchet, and Girardin have confirmed these figures and give 264-440 lb. per acre as a suitable dose.

Use against Injurious Plants.—Salt in excess is injurious, and certain plants stand it with difficulty. Wendler found common salt an excellent means of destroying charlock.

Destruction of Moss in Meadows and Weeds in Walks.—A strong dose of salt has a corrosive action on delicate plants; thus mosses and horse-tails which invade meadows succumb long before the gramineæ. Used on meadows and fields in a dose to kill moss, it only retards the growth of the gramineæ; applied on corn fields, it keeps the stem shorter, imparts a certain rigidity and prevents laying. Watering paths with a 10 per cent solution is the method used to destroy weeds; unfortunately it only destroys them momentarily and imperfectly because they spring up again as soon as rain comes to wipe out the treatment.

Use of Common Salt against the Diseases of Plants.—*Bacterian diseases of the potato, scab, crevices*, etc.—Becquerel experimented with common salt on the diseases of the potato. This product, in big doses, being an antiseptic, it might, therefore, prevent the extension of these diseases. The potatoes were planted in winter, and to prevent the frost getting at them the tubers were planted at a depth of 15 inches, with 10 grammes of salt, the others without any saline manure. In the salted ground the potatoes could be harvested two months before the normal time, and whilst on the ordinary soil there were 10 per cent of diseased potatoes, on the soils supplied with salt all the tubers were sound. Techemacher and Neumann came to the same conclusion, and according to Peters there is even an increased yield, but on the other hand a diminution in the total amount of starch. The same result occurs, therefore, as with the beet; the improvement brought to bear on this crop by common salt, and the increased yield are rather illusory, since as Grouven, Pingen, and Hert have shown, the weight of the beet increases whilst that of the sugar diminishes.

Peronospora Viticola, De By. (mildew of the vine).—Recommended in Germany towards 1882 the spraying of vines with a 2 per cent solution of common salt: having given no result, was soon abandoned.

Rust of Cereals.—Solutions of common salt were tried to combat this disease on the adult plants. Feburier and Phillipar obtained good results by spreading either salt or a mixture of salt and lime on the crop, but this improvement has been disputed by Loverdo.

Use in the Destruction of Insects.—Salt is not an insecticide, but its presence in the soil sometimes renders a sojourn there impossible or disagreeable to certain insects.

Agriotes lineatus, L. (wire-worm).—The larvæ of this insect have been combated by spreading a strong dose of salt on the fields. Comstock and Slingerland found that by mixing 10 tons of salt per hectare (4 tons per acre) with 10 centimetres (4 inches) of the arable surface soil these larvæ died; with only $7\frac{1}{2}$ tons per hectare (3 tons per acre), the effects were imperceptible. Unfortunately to obtain good results such large doses of common salt must be used that growth cannot take place normally; hence it has been advised to apply salt during the bare

fallow, as the latter is incapable by itself of diminishing the number of polyphagous larvæ.

Pieris (white cabbage butterfly).—The grubs of the *Pierides*, which ravage cabbages, may be destroyed by watering the latter with a solution containing 250 grammes of salt and 250 grammes of tobacco juice in 14 litres of water, say 1 lb. salt and 1 lb tobacco juice in 5-6 gallons of water.

Salt has been used to kill plant lice.

Phylloxera vastatrix, Planch. (phylloxera).—Salt, recommended by so many practical men to kill the phylloxera, has been found by Mouillefert as absolutely inactive. A dose inconvenient to this plant louse would be quite as injurious to the vine, because the latter dies if the soil contains a certain amount of salt. According to the experiments of Viola on the vine in pot, a dose of 200 grammes, say 7 oz., kills this plant in eight days.

Schizoneura lanigera, Hausm. (woolly aphis).—Krafft recommends the following emulsion, which yields a satisfactory result: Petrol 800 cubic centimetres, salt water, 25 per cent, 200 cubic centimetres.

Aspidiotus perniciosus, Comst. (the San José louse).—In California there is employed against this cochineal a mixture of lime, sulphur, and salt, but this preparation has been abandoned in the Eastern states owing to certain failures, and better results got by the use of whale-oil soap-emulsions.

Use of Salt to Preserve Green Fodder during Winter.—1. Plants mowed green are left on the ground for one or two days. They partially dry and lose about half their weight. They are then conveyed into rectangular pits, 1·7-2 metres deep, dug out of compact ground, clay, if possible. A layer of the mown plants is laid 15-20 centimetres (6-8 inches) deep, which is compressed under foot then sprinkled with a thin layer of salt. Another layer of plants is laid down, then a layer of salt, and so on, until the pit is completely full, and even to 1 metre (40 inches) or 1·3 metre (53 inches) above the level of the ground. Care must be taken to spread the salt in larger quantities on the edges and corners of the pit. The whole is afterwards covered with a layer of 60-70 centimetres (24-28 inches) of soil. The fissures produced during natural shrinking should be stopped. The cover is in the form of a sloping roof. This cover is absolutely necessary. For a ton of beet leaves it requires 2½-3 kilometres of salt, say 5·5 to 6·6 lb. The ensilage should not last more than two days. Fermentation soon commences, and reduces the mass to half its bulk. The fodder extracted from these silos may be given as food to animals without injuring their health.

2. Moist hay is dried and mixed with salt. Sinclair, Hell (? Hill), Kausler, Flandrin, and Schattenmann, recommended to sprinkle the different layers of hay with salt in proportion as they enter the silo. The salt absorbs the moisture and preserves the hay from all fermentation and mould. The dose should be 2 kilogrammes (4·4 lb.) per metric ton of hay.

26. Nitrate of Soda, $NaNO_3$.—**Occurrence.**—Nitrate of soda or

Chili saltpetre forms thick beds, which extend on the surface of the soil under a thin bed of clay.

Properties.—The crystals of nitrate of soda are anhydrous, permanent in dry air, but deliquescent in moist air. They are much more soluble in hot water than in cold water; 100 grammes of water dissolve 80 grammes of nitrate at 10° C. and 217 grammes at 119° C.

Action on Plants.—Nitrate of soda is a plant food, but like most salts in strong solution, it is injurious to certain plants. Steglich submitted the most diverse plants to a 30 per cent solution and to one of 15 per cent with the following results:—

TABLE XVII.—*Showing the Effect of a* 30 *per cent Solution A and of a* 15 *per cent Solution B of Nitrate of Soda on Different Plants.*

Plants.	*A*	*B*	*Plants.*	*A*	*B*
Grain .	Fleeting 5-7 days	Nil	Charlock .	Very sensitive	Very sensitive
Beets .	Nil	,,	Sorrel .	Nil	Nil
Potatoes	Deadly	Deadly	Knot grass	,,	,,
Trefoil .	Slight	Nil	Horsetail .	,,	,,
Lupine .	Deadly	Deadly	Peas .	,,	,,
Flax .	,,	,,	Mustard .	Deadly	Deadly

The property of nitrate of soda of killing certain plants without killing others has been utilized in farming to free fields invaded by certain adventitious plants. Duserre recommends the use of a 20 per cent solution to destroy mustard in cornfields. It is preferable not to use nitrate of soda alone, but mixed with a little blue vitriol. The young mustard dies after watering with a solution containing 10 per cent of nitrate of soda and 2 per cent of blue vitriol. Older mustard requires a solution containing 3 per cent of blue vitriol and up to 20 per cent of nitrate of soda; 10 hectolitres (22 gallons) of this solution are required per hectare (2½ acres). The use of nitrate of soda has, in this case, the advantage of serving as a manure to the grain crops, and by stimulating their growth renders them more apt to struggle against parasites. However, Nijpels believes that nitrate of soda, as the sole manure, encourages the development of the rust of cereals.

Action on Fungi.—Nitrate of soda should, logically, act like nitrate of potash on the spores of fungi. The latter salt has been studied in a very complete manner by Wuthrich.

Action on Insects.—Smith regards a 4 per cent solution of nitrate of soda as a good insecticide. Concentrated solutions of nitrate of soda spread on the land are injurious, according to Miss Ormerod, to the larvæ of the *Tipula;* according to Taschenberg, to the larvæ of the *Elaterides;* and according to Weiss, to *Nematodes,* and particularly to the *Tylenchus devastatrix,* Kuhn (eelworms of wheat), which cause the disease known as the *Niel du Froment.*

27. Arsenite of Soda, $Na_4As_2O_5$.—**Preparation.**—By boiling 1 part of arsenious acid with 2 parts of soda ash.

Properties.—Arsenite of soda is much more soluble in water

than white arsenic and consequently much more poisonous to plants. In the composition of arsenical bouillies its formation must be guarded against, or its effects neutralized by the addition of lime.

Use.—The soluble arsenites, such as the salts of potassium, ammonium, as well as the soda salt, have been serviceable owing to their great solubility and their immediate action on insects and injurious animals. But this use is, perforce, limited, and then can only be used to poison preparations to be eaten by insects and rodents.

Disinfection of Seed-Corn.—Boussingault proposed in 1856 to replace arsenic by arsenite of soda. He recommended to water gradually with constant stirring 2¾ bushels of grain with a solution of 200 grammes of arsenic and 600 grammes of soda crystals in a few litres of water. In an hour the grain was spread out to dry. This method was abandoned long ago.

Preparations to Kill Locusts.—In the British Colonies they prevent the migration of locusts by placing in their way bunches of fodder, herbs, or maize stems, steeped in a solution containing per hectolitre 60 grammes of arsenious acid, 60 grammes of caustic soda, and 10 kilogrammes of white sugar or molasses [or 60 oz. (wt.) of arsenious acid, 60 oz. of caustic soda by weight, and 1000 oz. of sugar (wt.) in 100,000 fluid ounces of water]. Drying is prevented by covering the bait with a board or a stone. This bait may be used for other insects.

28. Borax, $Na_2B_4O_7$.—**Occurrence.**—Borax occurs naturally in the lakes of Asia, from which it is extracted by evaporation and crystallization.

Preparation.—By gradually adding 100 lb. of Tuscan boric acid to 125 lb. of soda crystals dissolved in 20 gallons of water and then heating by steam. The mixture is concentrated to 30° B., and cooled slowly; crystals of borax form at the bottom of the receiver. The double borate of soda and lime, or boronatrocalcite, is widely distributed in America; it is now used to manufacture a large amount of borax obtained by boiling this product with carbonate of soda.

Properties.—Borax is freely soluble in water. A hundred lb. of borax dissolve in 120 gallons of cold water and the same amount in 20 gallons of boiling water. Its solutions react alkaline. Borax is used in medicine as an antiseptic, especially in throat and mucous affections. It is used to preserve meat and putrescible liquors. Wernoke found it more active from that point of view than boric acid. Its antiseptic and bactericidal capacity is, however, very weak. Kuhn found that it only acted in 2 per cent solution. Schwartz, however, found that the bacteria of the infusion of tobacco were exceptional, and that a 0·5 per cent solution had already a certain effect on these microbes. Wenckiewicz found that it had no action on *Penicillium glaucum* until its solution reached 1·4 per cent. Borax exerts a poisonous action on plants. By watering haricots with a very dilute solution of borax Peligot first induced chlorosis, then death.

Use.—Borax has been recommended in 5 per cent solution in America against the *Peronospora viticola*, De By. (mildew of the vine). At that strength it can circumscribe that disease, but its use is not

without drawback, for it burns the leaves of the vines treated. Care should be taken to wash these a few hours after treatment. Muhlberg found borax solutions did not kill the *Schizoneura lanigera*, Hausm., against which it had been recommended.

29. Carbonate of Soda, Na_2CO_3.—**Preparation.**—By the Solvay (Brunner, Mond) process principally. A concentrated solution of common salt is first saturated with ammonia, then a prolonged current of carbonic acid is passed through; bicarbonate of ammonia is produced, which acts on the common salt to convert it into carbonate of soda. The precipitate is filtered, drained, and calcined.

Properties.—Carbonate of soda crystallizes in prisms; the crystals lose their water of crystallization at the ordinary temperature. Heated, they melt in their water of crystallization, dry, and form calcined carbonate of soda (soda ash), which is an amorphous white powder containing no water. Soda crystals are much more soluble in hot water than in cold: the maximum solubility is at 38° C.; one gallon of water dissolves 6·04 lb. at 14° C., 166·6 lb. at 38° C., and 44·5 lb. at 104° C. Carbonate of soda in solution has a strong alkaline reaction.

Action of Carbonate of Soda on Plants.—Around alkali works the presence of this salt, carried by the wind, does much damage. Eventually the carbonate of soda, covering the leaves with a white layer, more or less thick, causes them to drop off, and kills the trees themselves. Rye suffers much from contact therewith; the ears are almost empty, and the few grains which they contain are shrivelled and blackish. When plants have been in contact with carbonate of soda the analysis of the ash reveals a quantity of soda superior to the normal quantity. The straw of cereals is more brittle, and contains less silica. Carbonate of soda acts like carbonate of potash; when it is a case of neutralizing the acidity of certain marshy lands carbonate of soda may play the part of lime, and the nitric ferments, which cannot act except in slight alkaline media, may thereby modify the flora of the field. In such conditions carbonate of soda, in small dose, may exert a favourable influence on vegetation.

Action on Fungi.—Wuthrich treated the spores of different fungi with sodium carbonate with the following results: A solution of 0·053 per cent prevents the conidia of the *Phytophthora infestans*, De By., from producing zoospores, but it does not injure their direct germination; life is only arrested by immersing the conidia in a 0·53 per cent solution As to the conidia of the *Peronospora viticola*, De By., Wuthrich found sodium carbonate more energetic; a 0·053 per cent solution hindered the growth of the spores, and a solution of 0·53 per cent stopped it entirely. The uredospores of *Puccinia graminis*, Pers., show, more than any other spores, a great resistance to carbonate of soda solutions, but germination is hindered by 0·53 per cent solution and stopped entirely by immersion in a 2·65 per cent solution.

Action on Insects.—All soft-skinned insects are sensitive to strongly alkaline substances, but these substances in themselves are not very powerful insecticides; they are, therefore, combined with toxic substances.

Use.—Carbonate of soda enters into the composition of certain

copper bouillies, but it has no other function than to decompose the blue vitriol into carbonate of copper and sulphate of soda. An excess of carbonate of soda must be avoided in the preparation of Burgundy or cuprosodic bouillies, because these evaporating on the leaves may give rise to the same bad effects as carbonate of soda and cause the leaves to drop. Carbonate of soda has also been recommended against plant lice, and chiefly against the woolly aphis, but Muhlberg has shown its inefficacy. According to Delacroix one of the best emulsions to use against lice is carbonate of soda 10 lb., soft soap 20 lb., petroleum 1 gallon, in 10 gallons water.

Note by Translator, re Arsenite of Soda, p. 108.—This substance is made a speciality of by at least one firm in Great Britain who sell it in a more or less concentrated state of solution. Several "accidents" have occurred from the solution having been drunk inadvertently, and some deaths occurred through leakage of a cask on to sugar casks during transit. What is known in medicine as Fowler's solution is a solution of arsenite of soda.

CHAPTER VII.

POTASSIUM HYDROXIDE (CAUSTIC POTASH)—POTASSIUM SULPHIDES (LIVER OF SULPHUR)—POTASSIUM CHLORIDE (MURIATE OF POTASH)—POTASSIUM NITRATE—POTASSIUM SULPHOCARBONATE—POTASSIUM XANTHOGENATE—POTASSIUM CYANIDE (PRUSSIC ACID)—POTASSIUM SULPHOCYANIDE.

30. **Caustic Potash,** KHO.—**Preparation.**—By decomposing carbonate of potash in solution in water by lime a precipitate of carbonate of lime is formed, and potassium hydroxide enters into solution :—

$$\underset{\text{Potassium carbonate.}}{K_2CO_3} + \underset{\text{Calcium hydroxide.}}{Ca(OH)_2} = \underset{\text{Potassium hydroxide}}{2KOH} + \underset{\text{Calcium carbonate.}}{CaCO_3}$$

Properties.—Caustic potash is a white deliquescent solid ; exposed to moist air it absorbs water and carbonic acid. Potash, even in dilute solution, is a strong caustic which softens and gradually dissolves the skin ; it traverses and perforates the mucous membranes ; it is a strong poison, which should be handled carefully. It is used in surgery as a cautery. [Antidote, vinegar.]

Use.—Potash solutions have been used in America against different plant lice, which, owing to the chitinous protections covering them, greatly resist insecticides. The caustic nature of potash gives access to the insect by removing these obstacles.

Psylla Pyricola, Forst. (psylla of the pear).—Slingerland tried to destroy the eggs of this insect, but, contrary to anticipation, caustic potash had not the desired effect. Bolley tried this substance to destroy potato scab, but found that a 0·5 per cent solution injured the formation of the eyes and germs, and that in 1·5 per cent solution it almost completely destroyed them.

31. **Potassium Sulphides,** K_2S to K_2S_5.—**Preparation.**—Potassium monosulphide is prepared from caustic potash ; by saturating a 30 per cent solution with hydrogen sulphide, potassium hydrogen sulphide and water are formed :—

$$KOH + H_2S = KHS + H_2O.$$

The same amount of 30 per cent caustic potash is afterwards added, which reduces the hydrosulphide to the monosulphide :—

$$KHS + KOH = K_2S + H_2O.$$

To obtain the polysulphides it suffices to heat the monosulphide with 1, 2, 3, 4 atoms of sulphur.

Liver of Sulphur is a mixture of polysulphides, but it contains especially the pentasulphide of potassium. It is preferably obtained by heating to redness in a crucible equal parts of sulphur and carbonate of potash. By the action of heat the carbonic acid is disengaged and the sulphur combines with the potassium. When the disengagement of carbonic acid is finished, the liquid is run on to an iron plate where it solidifies immediately; it is then broken up and preserved out of contact with air. It forms a reddish-brown solid which smells of rotten eggs.

Properties.—The sulphides are very deliquescent and soluble in water in all proportions. They must be kept out of contact with air; carbonic acid in presence of moisture rapidly decomposes them into potassium carbonate and hydrogen sulphide. Solutions of the monosulphide are colourless, those of polysulphides, on the other hand, are yellow. Sulphides retain the alkaline properties of caustic potash, attenuated by sulphur. In medicine, sulphides are used to treat skin diseases due to acarium. Plants do not stand spraying with sulphide solutions, these being generally used very dilute. The sulphuretted hydrogen given off by decomposition is poisonous to the plant in a 0·75 per cent dose, but it is only formed gradually, so that the amount in contact with the plant is not sufficient to cause any ill effect. Leaf burning is less frequent than with sublimed sulphur.

Use.—Sulphides are used to combat: (1) *Cryptogamic diseases*, either by spraying the plants or by immersion to disinfect the seed against anthracogenic parasites. (2) *To kill insects.* To impart more adherence and a longer action, a soap and glycerine emulsion is used. Polysulphides of potassium are used in the same proportion as sulphur, for they decompose under the action of carbonic acid and air and organic acids into potash salts, hydrogen sulphide, and sulphur:—

$$K_2S_5 + CO_2 + H_2O = K_2CO_3 + H_2S + 4S.$$

The sulphur is precipitated in a fine state of division, and thus its anticryptogamic properties are at a maximum. It can thus be said that the action of polysulphides is appreciably identical with that of sulphur, and especially of precipitated, impalpable sulphur if used in the same temperature conditions. In studying their application it will be seen that they have entered into current practice as substitutes for sulphur in killing numerous *Erysipheæ* and to stop the development and extension of certain fungi by the destruction of their *conidiophores*. In sulphides the caustic action aids that of sulphur. Not only do sulphides have a decided action on fungi and their spores, but the potassium carbonate formed by their decomposition has a decided action on fungi, whose growth it prevents. The growth of conidia of *phytophthora* and of *peronospora* is stopped by a 0·7 per cent solution, their zoospores being no longer able to develop. The spores of *Ustilago Carbo* and of *Claviceps purpurea* as well as the uredospores of *Puccinea* are more resistant than the former, for a 0·7 per cent solution hardly hinders their growth, whilst a 3·5-7·5 per cent solution stops it.

As insecticides, sulphides act in virtue of their caustic properties,

and the sulphuretted hydrogen given off by their decomposition, this gas being for insects almost as poisonous as prussic acid. It is, moreover, asserted in medicine that sulphides used in 5-20 per cent solution in skin diseases, such as itch, act on the parasites by the sulphuretted hydrogen formed in contact with the organic acids of the transpiration and the carbonic acid of the air.

Use against Bacteria.—Sulphides retard putrefaction and kill microbes (Amsler). It has been tried to utilize this property to treat plant diseases of bacterian origin, such as potato scab. The bacteria which causes this disease of the potato is found, according to Bolley, in the living tissues of the periphery of the tubers and never penetrates deeply; it is aerobic. Bolley has submitted tubers so attacked for twelve hours to the action of a 0·3-0·4 per cent solution of potassium sulphide before planting them. At that strength the causticity of the sulphide is not sufficient to injure the tubers. An appreciable effect was obtained, but the sulphide has not the radical effect of mercury bichloride. The results obtained by the sulphide are still defective—5 per cent of healthy tubers against 1 per cent in a blank field.

Gum Disease of the Olive (Mal di Gomma of the Italians).—Swingle and Weber advise to combat this disease by potassium sulphide: 18 kilogrammes (39·6 lb.) of potassium sulphide are dissolved in 15 litres (3·3 gallons) of water; to this paste 12 kilogrammes (26·4 lb.) of 98 per cent caustic soda are added and energetically stirred. The mass heats, boils, and melts. As soon as boiling is over the bulk is made up to 100 litres (22 gallons) with water. The cankers and wounds formed by the disease are cleaned, diluted before use with an equal bulk of water; the roots, even sound ones, are stripped and watered with a solution of this sulphide in 10 parts of water.

Use against Fungi.—Pickling of Seed-Corn.—Dilute solutions of potassium sulphide prevent the growth of fungi and their spores and may kill them if of a certain strength. The action of the sulphide is not the same on all spores, e.g. it is almost *nil* on the spores of *Phytophthora Phaseoli*, Taxter. (Lima bean mildew). Hitchcock and Carleton remarked that a 1 per cent solution not only did not destroy the uredospores of *Puccinia graminis*, Pers. (black rust) and *Puccinia coronata*, Corda (coronated rust of oats), but rather accelerated their germination. By numerous experiments on rusts Galloway came to the same conclusion. The disinfection of grain in 0·75 per cent solution made no diminution in the rust. By spraying winter wheat no appreciable result was obtained unless spraying with a 0·5 per cent solution was repeated every ten days. Under such conditions he obtained 1 diseased plant against 24 in the blank plot. If twenty days' interval occurred between the sprayings the rust did not diminish but the harvest was a little better. Kellermann and Swingle were the first to observe the sensitiveness of the spores of smut to sulphide, especially the loose smut of oats. Jensen tried if grain could not be disinfected by sulphide against smut. The results which he obtained were surprising, and he did not hesitate to advise it in place of steeping in hot water recommended by him some years

previously. The powder used in the beginning and known under the name "Ceres," is nothing more than potassium sulphide. The numerous experiments of Bolley, Rostrup, and Selby show, however, that the sulphide is not capable of rendering better services than the Jensen hot-water treatment or that of Kuhn's with blue vitriol or that by mercuric chloride. It generally gives very irregular and sometimes imperfect results, for example, against *Smut of Wheat* (Rostrup). It has, however, a serious application in the disinfection of oats, where it is superior to any other treatment in destroying the spores of *Ustilago Avenæ*, Rost. (loose smut of oats). This treatment is practised in Denmark where it is highly esteemed. Steeping should last twenty-four hours in a 0·75 per cent solution.

Helminthosporium gramineum, Eriks. (black mould of cereals).—Kolpin Kavn found steeping grain in the sulphide is a good precaution against this disease.

Spraying with Dilute Solutions.—The *Erysipheæ*, the mycelium of which is not protected by the tissue of the plant attacked, may be combated by potassium polysulphides. Owing to their decomposition the sulphur is deposited between the filaments spread on the surface of the organs attacked, and acts in a more certain manner than sulphur used against the same disease. In spite of their properties the sulphides of potassium are not used to combat the oidium. Gardeners use them against *Microsphæra Grossulariæ*, Wallr. (gooseberry leaf-mildew); *Sphærotheca Mors Uvæ*, B. et C. (American gooseberry mildew), which they cure radically. Close prefers a 0·3 per cent solution of potassium sulphide to the fungicides, usually employed by sol, formol, and bouillie bordelaise. Goff advises spraying with a 0·2—0·4 per cent solution as soon as the leaves appear, and to renew it after each heavy rain until the plants are completely in leaf, and from time to time in summer. He obtained the following results: The fruit garden check plots showed 11·3 per cent diseased plants, after 0·2 per cent treatment 7 per cent, and after 0·4 per cent 1·7 per cent of diseased plants.

Sphærotheca pannosa, Lev. (rose and peach mildew).—This fungus may be combated efficaciously by potassium sulphide. Vesque recommends spraying with 1 per cent solutions, Mohr 2 per cent liver of sulphur, to which he adds 2 per cent of glycerine to render it more active and adherent. A concentrated bouillie is prepared by dissolving 200 grammes of liver of sulphur and 200 grammes of glycerine in a litre of water (say 2 lb. of each in a gallon of water) and the solution kept out of contact with air until required for use, when it is diluted with ten times its bulk of water.

Sphærotheca Castagnei (hop mildew).—Salmon recommends 0·1 per cent solutions, Selby 0·2 per cent solutions.

Amongst the fungi living in the interior of plants which cannot be reached, a certain number may be combated by destroying the conidiospores which contribute to their rapid propagation. These are:—

Alternaria Brassicæ f. nigrescens, Peglion (scorching of the leaves of the melon).—Sturgis used potassium sulphide with much success.

Sphærella Fragariæ, Sacc. (spotting of the leaves of the strawberry).—Potassium sulphide has been used successfully in America by

Buffum and Arthur against this parasite of the strawberry to prevent its too great extension.

Guignardia Bidwellii, Viala et Ravaz (black rot).—Galloway obtained satisfactory results with 0·1 per cent solutions of liver of sulphur: blank vines 65·64 per cent of sound grapes; vines sprayed six times, 75·17 per cent of sound grapes. This treatment cannot compete with that of copper salts, because notwithstanding its less efficacy it is not quite harmless to the vine leaves.

Septoria Piricola, Desm. (spotting of the leaves of the pear).—Duggar used potassium sulphide with success, but found it less efficient than bouillie bordelaise.

Cladosporium fulvum, Cooke (tomato disease).—The mycelium, which extends between the cells of the parenchyma, cannot be reached, but the conidiophores may be destroyed. Liver of sulphur acts better than sulphur in this instance (Mohr).

Gloesporium frutigenum, Berk. (bitter or tardy rot of fruit).—To prevent this, Galloway and Nijpels spray the apples before maturity, in August, with a 0·4 per cent solution.

Fusicladium dentriticum, Fuckel (apple scab); *Fusicladium pirinum*, Fuckel (spots of the pear).—Gaff found that on apple-trees frequently sprayed with 4 per cent solutions of liver of sulphur from the birth of the leaves, and renewed after each heavy rain, the amount of diseased apples is appreciably diminished.

Use against Insects.—Potassium sulphide may be used as a caustic against delicate insects. It also destroys the tissues protecting grubs.

Acridides.—Dubois observed the great sensitiveness of grasshoppers (Locusta) and their eggs to potassium sulphide. These eggs touched by solutions of potassium sulphide do not hatch. Watering the soil with potassium monosulphide on the spot where the Acridides have laid their eggs may suffice to impede the invasions of the *Acridium migratorium* so formidable in Algeria.

Eriocampa adumbrata, Kl. (the pear-tree saw-fly).—Taschenberg recommends powdered fresh liver of sulphur spread like sulphur on the trees. Solutions of the sulphide are used with success against the caterpillar protected by a silky tissue which render them inaccessible to ordinary aqueous insecticides. Potassium sulphide by its caustic action softens and finally decomposes the tissues, and penetrates to the caterpillar which then dies owing to the sulphuretted hydrogen disengaged.

Conchylis ambignella, Hubn. (cochylis of the vine).—Schmidt-Achert recommends as very efficacious against this caterpillar a 2-5 per cent solution of liver of sulphur sprayed on the flowers and on the grapes; Schafer, on the other hand, did not obtain good results by this treatment.

Hyponomeuta Malinella, Zell. (hyponomeute of the apple-tree).—Bach found a bouillie made with 1200 grammes of soft soap and 200 grammes of liver of sulphur in 100 litres of water (say 12 lb., and 2 lb. in 100 gallons of water). This bouillie can be used with success against all caterpillars that live in company in a spun refuge.

Tingis Piri, Fl. (Tigre du Poirier).—Montillot recommends two or three coats with the brush in winter, at intervals of a fortnight, on the branches and trunks of pear-trees with a preparation made thus: 2 lb. of potassium monosulphide is dissolved in the requisite amount of water; it is withdrawn from the fire and 2 lb. of flowers of sulphur gradually added.

Plant Lice.—Moss recommends a mixture of soap and liver of sulphur, known in England as Chiswick compound, against lice in general. Thumen regards $2\frac{1}{2}$ per cent solutions of potassium sulphide as good. The phylloxera is absolutely refractory to the action of potassium monosulphide. Mouillefert tried it against that parasite by spreading 480 grammes per stock in a radius of 30 centimetres round root-stripped vines, and sprinkling them with 10 litres of water (2·2 gallons). As a matter of form, the following curious process, recommended by Ponsard, may be quoted: It consists in boring a hole with a gimlet into which 2-3 grammes of potassium sulphide was introduced; the hole was then closed with mastic. The author of this process hoped that the sulphide entrained by the jus would induce the death of the phylloxera, but this treatment has only given a negative result.

Phytoptides.—The acari, which by irritation of the tissues of the plant produce degeneration of the latter, become manifest by felt-like growths known as *erinoses* or by peculiar swellings of bright-coloured tints as is seen on the pear when it has the Cloque (brown rust), may be destroyed by the sulphides. Emulsions containing 3-4 per cent of sulphur must be used at the moment when the acari have not yet produced the excrescences which protect them so efficaciously. Smith and Williamson advise to treat chiefly the *Eriophyes Piri*, Pgst., *Phytoptus Piri*, by two sprayings, one before the opening of the buds, and the second after collecting the fruit, or even spraying with a concentrated emulsion in winter followed by a weaker one after plants have come into leaf.

32. Potassium Chloride (Muriate of Potash), KCl; **Potassium Sulphate**, K_2SO_4.—**Natural Occurrence.**—Potassium chloride is found (500 grammes per cubic metre) in sea-water. Potassium chloride and sulphate of potash form vast underground deposits at Stassfurth in Prussia and at Kalusy in Galicia. In these mines the different salt beds have a different composition. Below vast deposits of rock salt deposits rich in sulphate of potash are found under the form of triple sulphate of lime, magnesia and potash (*Polyhalite*), then sulphate of magnesia and potash (*Kainite*), and finally double chlorides such as *Carnallite*. Carnallite, for example, contains 16 per cent of potassium chloride, 20 per cent of magnesium chloride, 25 per cent of sodium chloride, 10 per cent of magnesium sulphate, and 29 per cent of impurities. For agricultural purposes these salts are generally used in the impure state as brought from the mine. If it be desired to purify them and to obtain pure potassium chloride, the saline mass is pulverized and dissolved in large cast-iron steam-heated vessels. The solution is allowed to deposit, then decanted, and left to crystallize; the potassium chloride crystallizes, entraining with it a little magnesium and sodium chlorides which are removed by washing with cold water. If potassium chloride be treated with sulphuric acid,

which is done commercially in cast-iron vessels, hydrochloric acid is given off and potassium sulphate formed.

Properties.—Potassium chloride is very soluble in pure water. 320 grammes dissolve in 1 litre of water at 10° C., 570 grammes in 1 litre at 100° C. Potassium sulphate is less soluble, a litre of pure water dissolves 84 grammes at 0° C. and 260 grammes at 100° C.

Action on Plants.—Potash is a necessary plant food. In soils where potash is quite absent plants languish and finally die before maturing their seed. Such soils are rare. They are such as contain a large proportion of limestone, peat, or sand. Potash may be given to the plant as potassium chloride as well as the sulphate or nitrate. The crude salt from the mines is generally used for the purpose. If soil be dissolved by aid of sulphuric and hydrofluoric acids, and if the potash which it contains be isolated, enormous amounts are found per hectare. The German agronomists calculate this amount at 30-40 tons per hectare (12-16 tons per acre). Berthelot found 35 tons at Meudon (14 tons per acre) and Deherain 32 tons at Grignon (12·8 tons per acre). This potassic mass is not in a state of soluble chemical combination, but it may be dissolved by the acid juices of the roots which it appropriates in sufficient amount. When potassic manures are added to soils of this nature, and they form the great majority, no benefit accrues to the plant, and the spots where they are applied cannot be recognized, no increased yield being obtained. Potassium manures are only useful as a supplementary material when the soil does not contain it in any form. Then its influence makes itself felt especially when the crop is sustained by other chemical manures such as sulphate of ammonia, nitrate of soda, and superphospate. Farmyard dung which contains 5 kilogrammes (11 lb.) of potash per ton, suffices with the (potash) salts contained in the soil to meet the requirements of agriculture. The belief of the great efficacy of potash salts in all soils, established by Liebig, has not been confirmed in practice. An excess of potash salt may, on the contrary, be injurious to certain plants. Heinrich was the first to observe the injurious effects of certain salts, such as potassium chloride and magnesium chloride, nitrate of soda and sulphate of ammonia on adventitious plants. Steglich has specially studied the action of potassium chloride on farm crops with the following results:—

TABLE XVIII.—*Showing the Action of a 30 per cent Solution and a 15 per cent Solution of Potassium Chloride (Muriate of Potash) on Farm Crops.*

Crop.	*30 per cent Solution.*	*15 per cent Solution.*	*Crop.*	*30 per cent Solution.*	*15 per cent Solution.*
Grain . .	Injurious fleeting	Disappears in 5-8 days	Lupins . .	Deadly	Deadly
			Flax . .	,,	,,
Beets . .	Nil	Nil	Mustard . .	,,	,,
Potatoes .	Deadly	Deadly	Charlock . .	Very injurious	Nil
Peas . .	,,	Slight	Sorrel . .	,,	Slight
Haricots .	,,	,,	Polygonium .	Deadly	Nil
Trefoil .	Nil	Nil	Horse-tail .	Injurious	,,

On the other hand, a 6 per cent solution of kainite has no injurious effect on the most tender part of the plant.

Use.—As Pickle for Seed-Corn Smut.—G. Arieti tried to disinfect seed-corn against smut by steeping it for twenty-four hours in a 0·5 per cent solution. At that strength potassium sulphate has no injurious action on the germination of the grain, but neither is its action on the spores very pronounced. A 2 per cent solution renders the spores of *Tilletia* (bunt) inactive, but the seed already suffers. G. Ville, having observed that a want of potash in the soil seems to favour the development of the *Phytophthora infestans*, De By. (potato disease), recommended the use of potassic manures to combat it in a preventive manner. Care must be taken, however, not to use larger quantities than 600 kilogrammes per hectare, say 528 lb. per acre, for at that dose potash salts diminish the yield in starch. These salts are also employed against phanerogamic parasites, such as dodder.

Cuscuta epithymum, Murray (dodder of trefoil and lucerne).—Their sensitiveness to metallic salts is very great, and these parasites may be easily destroyed by watering the fields with such solutions. In the same way as the sulphates of iron and copper, green and blue vitriols, which give good results, the sulphate of potash may also be used. Vesque recommends to dust with this product in a heavy morning dew the plots invaded by dodder. Next morning, after this treatment, the fields of trefoil and lucerne present a lamentable appearance; all the plants are brown and look as if burned, but the effect of sulphate of potash on leguminosæ is only fleeting, and in eight days these plants have resumed their vitality, whilst the dodder is destroyed to such an extent that it does not reappear the following year. The dose to use is from 200-250 grammes per square metre, say 7-8 oz. per square yard.

Equisetum arvense, L. (meadow horse-tail).—This plant, which contains aconite, is injurious to cattle. Tacke advises, to free crops infested with it, to water them with a concentrated solution of potassium sulphate; the gramineæ can resist this treatment, whilst the horse-tails died.

Heterodera Schachtii, Schm. (nematode of the beet).—As a sequel to Liebig's researches, concluding that potash is a necessary food of this plant, it was observed that potash salts used in beet growing, up to a certain dose, remedied the exhaustion of the soil. Kuhn sided with the general opinion that such salts acted by their nutritive properties and replaced the potash removed by the beet. Webster and Hopkins still hold this opinion and deny the insecticide action of potash salts. But after it was found that the exhaustion of the land by this crop was due in great part to an excessive growth of small worms, *nematodes*, Hollrung tried the action of potash salts on their larvæ. He remarked that the latter, more sensitive than the adults, died in forty-eight hours in a 1 per cent solution of potassium chloride and in three hours in a 5 per cent solution. Potassium sulphate is less active in a 1 per cent solution as it takes ninety-six hours' immersion to destroy the larvæ, and has the same toxicity as potassium chloride in

a 5 per cent dose. To succeed, the dose used must be considerable; instead of using pure sulphate, the double salts from the mines, kainite or carnallite are used, but these are less active than the pure salts. Hollrung has observed that in big doses these salts are unfavourable to the formation of sugar in the beet. There are no great advantages in using potassium chloride or sulphate in massive doses to remedy the exhaustion of the land, for the effect is somewhat illusory. This practice has moreover been abandoned since, as the outcome of Aimé Gerard's researches, arable land may be sterilized by large doses of carbon disulphide.

Agriotes lineatus, L. (striped wire-worm).—Comstock and Slingerland ascribe insecticide properties to potassium sulphate against the adults. Smith regards a 12 per cent solution of kainite as an excellent insecticide. But Marlatt, who used big doses of kainite, against wireworm (Elaterides, click beetles), got no appreciable result. Mineral manures such as potash salts injure certain parasitic larvæ, e.g.:—

Lachnosterna fusca, Fröhl (May beetle); *Lachnosterna arcuata*.—Chittenden found kainite very active. Possibly the larvæ of the Elaterides which are very mobile flee from soils which have been treated with big doses of potash manures. Opinions are too contradictory to admit that potash salts kill them.

Agrotis segetum, W. V. (common dart moth).—The grey worm, the caterpillar of this butterfly, is driven off or destroyed by watering the infested spots by a 12 per cent solution of kainite.

Jassus sexnotatus, Fall.—Steglich uses kainite in a composition to combat this grasshopper: kainite 10 lb., carbolic acid 1 lb., soft soap 10 lb., in 100 gallons of water.

Snails.—Kainite is a specific against snails (Taschenberg).

33. Nitrate of Potash, KNO_3.—**Occurrence.**—Nitrate of potash, or saltpetre, occurs in nature; it is found in the great plains of China, India, and Egypt. It is extracted by removing the nitrated earth for a few centimetres and lixiviating it. The liquor is then run into large basins and evaporated in the sun.

Preparation on the Large Scale.—By double decomposition of sodium nitrate and potassium chloride. By hot concentration of the solution the sodium chloride formed crystallizes, whilst the saltpetre, much more soluble when hot than common salt, remains in solution and does not deposit until after cooling.

Properties.—Saltpetre is very soluble in water, 10 gallons of water dissolve 15 lb. of saltpetre at 9° C., 85 lb. at 15° C., 246 lb. at 100° C. (212° F.), 335 lb. at 118° C. At a great heat [igneous fusion] saltpetre is a powerful oxidizing agent.

Action on Plants.—Potassium nitrate like potassium chloride is a plant food, and what has been said anent potash salts applies to potassium nitrate.[1] Concentrated solutions injure plants.

Action on Fungi and their Spores.—Wuthrich's researches on the action of metallic salts on the spores of fungi also include potassium

[1] *Translator's Note*.—But the nitric acid is the predominating agent of potassium nitrate, and as a plant food puts it beyond comparison with other potash salts, the phosphate excepted.

nitrate. The growth of the conidia of *Phytophthora infestans*, De By., is not stopped by an 0·1 per cent solution, but the formation of zoospores is prevented. The growth of the conidia is not hindered until a 1 per cent solution is used. The zoospores are at once killed by this solution. The spores of *Peronospora Viticola*, De By., are a little more sensitive. A 0·01 per cent solution hinders their growth a little; with a 0·1 per cent solution the conidia cannot form zoospores. Their motion is slackened, and after fifteen hours none reach their normal growth; a 40·4 per cent solution interferes with the growth of *Ustilago Carbo* (smut), a 50·5 per cent solution stops it. A 50·5 per cent solution lowers the vitality of the spores of *Puccinia graminis*, Pers., but they are only killed with a 101·1 per cent solution. A 101 per cent solution does not destroy the vitality of the spores of *Claviceps purpurea* (ergot), Tul. Nitrate of potash therefore, even in strong doses, is deficient in real anti-cryptogamic properties. It has no toxic action, but merely exerts an unfavourable effect on the development of the spores by producing plasmolysis. Like many substances, potassium nitrate acts as an astringent when it is used in concentrated solution. As such it may prevent all cryptogamic evolution, but that is all its effect. If the spores, the growth of which has been momentarily suspended, are washed and replaced in good conditions, they generally develop normally.

Use.—*Nematus Ribesii*, Scop. (gooseberry and currant saw-fly); *Abraxas grossulariata*, L. (the magpie moth).—Taschenberg uses against these two gooseberry pests a spray of a 1·2 per cent solution of nitrate of potash.

34. Carbonate of Potash, K_2CO_3.—**Preparation.**—The impure commercial potash is obtained by incinerating terrestrial plants. This incineration is done where there are many forests and where the means of transporting wood are difficult. The ashes obtained, which do not contain more than 5-20 per cent of carbonate of potash, are washed in casks and are exhausted after three or four washings. The collected liquors are evaporated and yield the salt which calcined in contact with air furnishes commercial potash, consisting mostly of carbonate of potash with a small amount of potassium sulphate and chloride.[1]

Properties.—Deliquescent. Dissolves in its own weight of water. Reaction strongly alkaline.

Action of Carbonate of Potash on Plants.—Used in agriculture carbonate of potash by its alkalinity plays the rôle of lime, i.e. it corrects the acidity of the soil and utilizes the nitric ferments which can only work in a slightly alkaline soil. The nitric acid so formed increases the crop. Carbonate of potash can thus greatly alter the flora of an acid meadow. The reeds and rushes of the acid land disappear to the benefit of the useful gramineæ and leguminosæ. This

[1] *Translator's Note.*—Fabulous amounts of potash are produced in Russia by the incineration of sunflower stalks, and a big trade is done both with London and New York in such potash. But as Fritsch well points out, to grow any plant as a source of potash would be to go round in a vicious circle (see Fritsch's "Chemical Manures," Scott, Greenwood & Son, which gives a detailed description of all German potash mineral salts).

sensitiveness of plants belonging to the Cyperaceæ and the reeds has been often remarked, and this product is utilized to destroy them. Noffray spreads wood ashes on meadows in wet weather or after a strong dew; the reeds and the rushes are burned and the leguminosæ grow rapidly. The injurious action of carbonate of potash is not limited to these plants alone, it is very decisive on dodders, mosses, and lichens. The first are destroyed by spreading wood ashes on the clover fields in dry weather and watering afterwards. The result is satisfactory, but it cannot be compared to that got with green vitriol, for there often remains after treatment some immune parts which contribute to the propagation of the disease. Carbonate of potash may replace lime against mosses and lichens. Sorauer replaces the common process of liming the trunks of trees by coating them with a solution of 15 lb. of carbonate of potash in 15 gallons of water. This treatment not only frees the tree from the parasites sheltered under the fissures of the bark but does not colour the tree white like lime.

Action on Fungi.—Alkaline carbonates have no toxic action on spores of fungi, but at a certain strength they impede their growth. Tillet who observed this action found it sufficient to guarantee the seeds of black wheat. Disinfection by the lye from wood ashes has given appreciable results.

Plasmodiophora Brassicæ, Woronine (finger and toe).—As a preventive, Nijpels waters with carbonate of potash against the finger and toe so as to kill the spores of the myxomycetes and prevent infection of young plants.

Action on Insects.—Soft-skinned insects are generally very sensitive to alkaline substances and may be combated therewith. Soft soap and lime are of great service; carbonate of potash acting similarly has been recommended by some observers.

Crioceris Asparagi, L. (the asparagus beetle).—The larvæ of this Coleoptera is very delicate and may be destroyed by spraying with the lye from wood ashes.

Haltica (ground flea beetle).—To prevent these voracious Coleoptera from gnawing the young plants growing in the fields in the spring, Montillot spreads wood ashes on the seed beds. It is chiefly against the different species of plant lice that carbonate of potash has been found useful.

Schizoneura Lanigera, Hausm. (the woolly aphis or American blight).—Taschenberg uses lye from wood ashes to destroy this insect, but Muhlberg found this method ineffective.

Phylloxera vastatrix, Planch.—Mouillefert found potassium carbonate ineffective.

Aspidiotus perniciosa (San José louse).—Marlatt made numerous attempts to destroy this apple bug so formidable in America, and obtained with 24 lb. of lye in 10 gallons of water, 85 per cent lice killed; with 12 lb. 75 per cent; with 6 lb. 50 per cent; with 3 lb. 20 per cent. Carbonate of potash in itself acts injuriously on the lice, and as it is at every one's disposal it may be tried in certain cases. But it will act more surely if it be used as an aid to certain toxic substances, petroleum, for example. Alkaline products, in fact, act on the mucus

and the chitin so as to let the toxic substances reach the parasite and act on it more rapidly.

Wood ashes are also utilized to kill slugs, using preferably that from lime-kilns, as it still contains lime, the action of which aids the carbonate of potash. After a rain in the evening the ashes are spread broadcast on the seed beds of whatever nature ; it exerts no injurious action on the plant but kills snails instantly on touch. It is well to water the plants next morning and recommence the treatment after sunset. In vineyards where slugs are dreaded vines are heavily dusted with ashes.

35. Potassium Sulphocarbonate, $K_2CS_3H_2O$.—**Preparation.**—By agitating potassium monosulphide K_2S, with an excess of carbon disulphide. If a pure product be not desired liver of sulphur may also be used.

Properties.—Carbon disulphide acts as an acid towards alkaline sulphides and forms compounds therewith analogous in constitution to the alkaline carbonates K_2SCS_2.

But these compounds are unstable; the moisture and carbonic acid in the air decompose them thus—

$$K_2CS_3 + CO_2 + H_2O = K_2CO_3 + CS_2 + H_2S$$

into alkaline carbonate, carbon disulphide, and sulphuretted hydrogen. Organic acids act in the same way. This decomposition goes on slowly in the air and in the soil, according to the moisture of the surrounding media and the richness in carbonic acid. The dry crystals contain 38 per cent of carbon disulphide and can disengage 17 per cent of sulphuretted hydrogen ; 100 grammes of 40° B. commercial solution, which tests 55 per cent of pure potassium sulphocarbonate, can give off on decomposition 20 per cent of carbon disulphide, say 6 litres, and 9 per cent of hydrogen sulphide, say 6 litres. Potassium sulphocarbonate is in the solid condition a yellow crystalline very deliquescent body. But it is very difficult to obtain in that form, and the commercial article is liquid and marks 35°-40° B. It is soluble in water in all proportions. [Alkaline sulphocarbonates treated by hydrochloric acid, then taken up immediately by water, yield a reddish-brown insoluble liquid which represents sulphocarbonic acid ; it is used in therapeutics. It readily decomposes into CS_2 and H_2S. The sulphocarbonates which chemically contain carbon disulphide have no analogy with the sulphide mixed with tar, vaseline, oil, or soap, the use of which has been proposed to replace the pure sulphide.]

Action on Plants.—Sulphocarbonate when concentrated is a violent plant poison. The two gases [CS_2 and H_2S] which it liberates are likewise poisons, but their action is less energetic than that of the sulphocarbonate itself. Trials on healthy vines in 3-litre pots at different seasons of the year show that the vine is more sensitive in summer during the activity of the sap than in winter. Thus in August, vines do not stand a dose of 12 cubic centimetres of 40° B. with or without water, whilst a dose of 15 cubic centimetres may be given in winter, and even in April when already the vine has big buds. Now 15 cubic centimetres of sulphocarbonate of 40° B. can only disengage 3

grammes of carbon disulphide and 1·35 gramme of sulphuretted hydrogen, quantities which are supported by the vine in similar conditions, especially in emulsion in water. It takes more than 6 cubic centimetres of sulphide emulsified in 60 cubic centimetres of water to kill the vine at that period. Young adventitious plants (*Mercurialis annuæ, Polygonum aviculare, Calendula arvensis, Borrago officinalis, Erodium cicutarium, Ictaria viridis*) vegetating in the open air were treated at end of August with 100 cubic centimetres of sulphocarbonate of potassium or sodium of 45° B., reduced so as to make 2 litres of mixture, and spread in five holes in a square of 20-inch side; the plants only suffered in the immediate neighbourhood of the holes. Haricots planted in pots containing 2 litres of soil resist perfectly when watered with 250 grammes of a 2 per cent solution of 45° B. potassium sulphocarbonate. Now, in practice, such strong doses are never used against insects. The toxic effect of potassium sulphocarbonate on plants is therefore almost negligible, whilst the dose is always poisonous to insects in a 0·0005 per cent solution.

Action on Fungi.—Like carbon disulphide potassium sulphocarbonate in strong doses exerts an injurious action on the mycelium of fungi and their spores. Dufour and Mouillefert tried this compound to replace carbon disulphide against root blight, *Dematophora necatrix*, Hartig. They did not, however, obtain the good results which they anticipated. Dufour only registered 15 per cent of cures after treating the stocks of vines suffering from the blight by a 2 per cent solution at the rate of 3-5 litres per stock. It is true, that in these trials Dufour is far from having fed into the soil a dose of 150-200 grammes of carbon disulphide per square metre, as is the case in the treatment of root blight by carbon disulphide, for the 100 grammes of liquid sulphocarbonate used in this case only contained 15 grammes of sulphide. Sulphocarbonates cannot replace the sulphide in the treatment of root blight, for they are much dearer. It is only when the dose of sulphide is minimum, as in the case of some insects, that the sulphocarbonates present real advantages over carbon disulphide.

Action on Insects.—Sulphocarbonates, owing to their composition, are almost equally as efficient as potassium cyanide. The most dilute solutions have a manifest and rapid action on insects. Mouillefert examined very exactly the limit of action of sulphocarbonates used against the phylloxera in different ways.

1. *By contact.*—By dipping the insects into dilute solutions, 1 in 200 of sulphocarbonate of 38° B., the insects were found dead in a quarter of an hour; in 1 in 500, in one hour; in 1 in 1000, in one hour fifteen minutes; in 1 in 5000, one hour; in 1 in 10,000, two hours fifteen minutes; in 1 in 100,000, in twenty-four hours. In a blank flask only containing water the insects were not dead in twenty-four hours. The potassium sulphocarbonate of 38° B. used in these trials not containing 50 per cent of dry sulphocarbonate, it may be said that the action of this product is deadly to the phylloxera in twenty-four hours in a 1 in 200,000 solution, say 0·0005 per cent of dry salt.

2. *By the toxic vapours* disengaged by the decomposition of the

sulphocarbonates. In a 2-litre flask with moist sides into which $\frac{1}{2}$ cubic centimetre of sulphocarbonate of potash of 40° B. had been run, the phylloxeras of an infested root suspended in this flask were killed in three hours. By running in 4 cubic centimetres of this product the insects were killed in half an hour. Now $\frac{1}{2}$ cubic centimetre contained 0·354 of dry sulphocarbonate capable of emitting by decomposition 0·14 gramme of carbon disulphide, or 40 cubic centimetres, and 0·06 gramme of sulphuretted hydrogen, or 40 cubic centimetres of gas, giving a total of 80 cubic centimetres of poisonous gas. It may therefore be concluded that $\frac{1}{2}$ cubic centimetre of sulphocarbonate is capable of producing in 2 litres of air an atmosphere with 4 per cent of toxic gases.

In trials with $\frac{1}{10}$ cubic centimetres of sulphocarbonate, or with 100 cubic centimetres of a 0·1 per cent solution, capable of producing 16 cubic centimetres of poisonous gas, and consequently an atmosphere of 0·8 per cent, the insects were killed in twenty-four hours. Now it is admitted that sulphuretted hydrogen destroys the phylloxera in twenty-four hours when the air contains 1 per cent of this gas, and carbon disulphide when the atmosphere contains 0·5 per cent of its vapours. It has been seen that the sulphocarbonate of potash disengages the same volume of these two gases. It follows that a mixture of equal volumes of sulphuretted hydrogen and carbon disulphide in the gaseous state would kill it in twenty-four hours with a solution of 0·75 per cent strength. The result obtained is thus appreciably the same as that found for sulphocarbonate of potash. The mixture of the two gases produced by the decomposition of the sulphocarbonates kills the phylloxera in the same time as a mixture of the same quantities of these two gases acting simultaneously. But sulphocarbonates do not act only when they enter into decomposition, their solutions are in themselves powerful insecticides. Whilst both gases produced by the decomposition do not kill the phylloxera except at 0·0015 per cent the sulphocarbonates in solution kill at 0·0005 per cent. Sulphocarbonates may thus be regarded as the most powerful of disinfectants, their aqueous solution being three times more powerful than sulphuretted hydrogen gas and carbon disulphide. Owing to this property, alkaline sulphocarbonates may be used to distribute through the soil substances highly poisonous to insects. There is no difference in the action of the different salts of sulphocarbonic acid, potassium sodium, or calcium salts, but the former are generally used because they possess the advantage of carrying into the soil a certain amount of potash, which, in certain circumstances, may contribute to the rapid reconstitution of the damaged root system. The doses used in the laboratory to kill the phylloxera are not those which are of use on the large scale, because many causes contribute to reduce their efficiency. The doses tried by Mouillefert were at first very strong, and killed the vine, treated as well as the parasites. The soil was watered from small vats near the stocks with a solution of 400 cubic centimetres of sulphocarbonate of potash of 38° B. in 5 litres of water, then with 8 litres of pure water. In other cases he used 220 cubic centimetres of sodium sulphocarbonate of 45° B. dissolved in $\frac{1}{2}$ litre of

water, distributed in four holes 60 centimetres deep placed in a radius of 35 centimetres around the stocks. The dose of 20 cubic centimetres of sulphocarbonate of 33° B. sufficed to kill the phylloxera without injuring the vine, but it is preferable to use per stock 50-80 centimetres of sulphocarbonate at 37·2° B. dissolved in 10 litres of water to obtain complete success.

Use.—Sulphocarbonates were examined so as to be utilized in vine-growing in the destruction of the phylloxera. The results obtained against this louse by *sulphocarbonation* led to this treatment being tried on other insects on which it has also given good results.

Phylloxera Vastatrix, Planch. (phylloxera of the vine).—*History.*—In the *séance* of 8 June, 1874, Dumas proposed the sulphocarbonates for the destruction of the phylloxera, indicating at the same time a practical method for their manufacture. The Department of Agriculture and the *Academie des Sciences* entrusted therefore two delegates, Cornu and Mouillefert, to make the necessary experiments to determine if the predictions of the learned chemist would be realized. Mouillefert made numerous experiments at the Cognac Viticultural Station, and was able to conclude that the sulphocarbonates, and especially potassium sulphocarbonate, were marvellous insecticides and also the best remedy against the phylloxera. In his remarkable research on the chemical products proposed for the destruction of the phylloxera he places the sulphocarbonates in the first rank of efficiency, and declares them to be alone capable to keep a vine attacked by the phylloxera in a thriving condition, and to regenerate it if weakened by the disease.

In numerous experiments on vine stocks placed in different conditions of soil, age, and cultivation, the sulphocarbonates always effected an improvement. Those greatly attacked by the phylloxera had lost all their root hairs, and of which a part of the radicles was attacked were, after a year's treatment, finer plants than the non-diseased stocks. The stocks still more badly diseased and almost in the last extremity were appreciably improved and did not die like the untreated blanks.

Mouillefert in 1876 published the conditions which it is indispensable to observe to secure good results by this treatment. The useful application of alkaline sulphocarbonates to the cure of the vine requires: (1) That all the infected surface be treated. (2) That the poison be injected deep enough to reach all the phylloxera. The best method to secure perfect diffusion in the soil is to use water as the vehicle. The amount used may be greater, or less, according to the state and conditions of humidity in the soil, and according as it may be expected to rain, or not, but water cannot be completely suppressed. The more water added, the more complete the diffusion and rapid the action. The amount of sulphocarbonate required to treat a square metre to a depth of 80 centimetres, 31·2 inches, which gives 800 litres, say 1 cubic yard, of soil, is 30-40 cubic centimetres, 1-1$\frac{1}{3}$ fluid oz., which is comparatively very little. Without the aid of water it would be very difficult to distribute this small volume on the surface of the soil and equally impossible to cause it to descend to a sufficient depth to kill all the insects unless the soil be very permeable or rain falls at

a propitious moment, which is exceptional. In all cases the direct use of water suffices if the quantity be abundant, whether the soil be compact, stony, or permeable, diffusion is always perfect. Alkaline sulphocarbonate solutions of 1 in 10,000 and even 1 in 20,000 being still poisonous in cultivation on the large scale, too great dilution need not be feared, in rendering diffusion more perfect, to make the remedy impotent. The best method of using sulphocarbonates consists in making flat receptacles in the soil, round the foot of each vine, and there distribute the poison. For this purpose 500 kilogrammes per hectare (440 lb. per acre), say 50 grammes per square metre, are diluted in 350 times its weight of water. After having poured the solution into the excavations it is well to pour on a little water to cause the poison to penetrate more deeply. When all the water is absorbed by the soil, the ground is put back into the pit and tramped down under foot. Sulphocarbonates may be used at any time of year, for the small dose has no effect on the plant, but it is preferable to use them whilst the sap is at rest. The water required to carry the poison into the depths of the soil being sometimes an obstacle to its use in many districts, the most convenient time for the application of sulphocarbonates is, then, that when rain is most abundant during winter, when the soil is already saturated with moisture. For small or medium scale cultivation, the best plan consists in placing the amount of sulphocarbonate required for a stock, say 50 grammes ($1\frac{3}{4}$ oz.), in a 10-litre (2·2 gallon) watering-can, then to pour into each pit the entire contents of this watering-can, and afterwards pour an entire watering-can full of water on each stock. But it is preferable when possible to make a dilute solution in a large reservoir, and to draw out with the watering-can the amount required for each stock. On the large scale, Mouillefert and Hembert have designed plant intended to bring the water required for the treatment into vineyards. It consists of a steam engine, working suction and propelling pump which can send the water several kilometres, and to a height of 100-150 metres (328-492 feet). The pump, placed near a river or a lake, sends the water into a distributing channel forming a network of ramifications through the vineyard. The channels of the third order end in metallic vessels of 350-400 litres (77-88 gallons) in which the sulphocarbonate is dissolved; the workmen there draw the amount of insecticide required, and spread it with the watering-can around the stocks. With good organization the workmen need not carry the water more than 10 metres, say 33 feet. A man can then spread 1500-1800 litres, say 330-396 gallons, of water an hour round the vines. By this ingenious process, vines far from a source of water may be treated. But owing to the large amount of water required, which is 150,000 litres per hectare, say 60,000 litres (13,200 gallons) per acre, being awanting in many districts, this treatment has not been adopted everywhere. Its use also finds a drawback in the fact that the cost of sulphocarbonating is greater than sulphuring. It costs in fact 300-350 francs per hectare (120-140 francs, £4 16s.-£5 12s. per acre). It is true that it brings potash to the value of 50 francs per hectare, 16s. an acre, on to the land, but that is only really useful in districts where potash is

deficient. Sulphocarbonates have therefore their place only in rich vineyards like those of Champagne, Burgundy, and Bordeaux. They should be preferred to carbon disulphide, the more so as they are much less dangerous for the vine. As Foex justly remarks, it is a process to use in *de luxe* vineyards. There are in France vineyards that have been submitted to this treatment for fifteen years, and still in good condition. In France there are hardly more than 10,000-12,000 hectares (25,000-30,000 acres) treated annually by sulphocarbonates, and since the carbon disulphide treatment has been better studied this figure has a tendency to diminish, for the carbon disulphide treatment, like the sulphocarbonate, being annual the small doses of sulphide used in such conditions are not prejudicial to the vine and enable it to be kept in a good state of production. Unfortunately, whatever care be taken in applying these substances there will always be a certain number of phylloxera which escape the toxic action. If, theoretically, the sulphocarbonates are capable in small doses of entirely destroying the insects on the roots, it is not so in practice even in much stronger doses ; different causes prevent the result from being so complete. But by the treatment the number of the phylloxera is so reduced as to enable the root hairs formed during the fine weather not to be entirely destroyed, and for the plant to nourish itself on the revival of vegetation. If the evil be not entirely removed it no longer forms an obstacle to the vine maintaining its vigour. The important point is to diminish the parasites, so that the vine may live with them without the crop suffering. The use of water as the vehicle of the sulphocarbonate being the great obstacle to the propagation of this marvellous insecticide, it has been tried whether mixtures with slaked lime would not likewise bring about a uniform distribution of the sulphocarbonates in the soil. It was Dumas who advised Mouillefert to try these mixtures, hoping that the lime, before its transformation into carbonate, would absorb the carbonic acid of the air and prevent the sulphocarbonate decomposing rapidly. In this way a powder would be got easily spread in the soil at the foot of the stocks, which would preserve the alkaline carbonate intact whilst waiting for rain to carry it into the neighbourhood of the infected roots. Mouillefert, therefore, mixed 500 cubic centimetres of sulphocarbonate of potash of 37° B. with 1·2 kilogrammes of lime in powder and spread this mixture in winter at the foot of five stocks, previously stripped to the big roots on a radius of 35-45 centimetres ; the earth was then put back into the holes. A fortnight later after a series of heavy rains the roots were examined ; on all the top roots the insects were dead, but on the roots more than 40 centimetres (say 6 inches) the insects were not found dead until two months afterwards. Success would have been complete if it had not been that on the roots beyond the stripped radius the phylloxera were still living. According to the predictions of Dumas, the use of sulphocarbonate in these conditions may suffice, provided the mixture be spread all over the vineyard. To attain this object the proportion of lime must be increased greatly, and a mixture of 500 kilogrammes of sulphocarbonate with 5000 kilogrammes of slaked lime applied per hectare of vineyard (say 440 lb. and 4400 lb., 2 metric

tons per acre). After spreading it would suffice to hoe the ground so as to mix it with the earth and protect it from contact with the air which would decompose it. From Laugier's experiments it would appear possible without hurting the vine gradually to extinguish the hotbeds of phylloxera infection, by aid of repeated mixed treatments of sulphocarbonate of potassium and carbon disulphide, applied opportunely and in suitable doses. This process, much used in Switzerland and Italy, appears to leave nothing to be desired.

Disinfection of Vines and Graft Bearers.—Sannino advises for this purpose sulphocarbonate of potassium in 0·05 per cent solution; for disinfection to be complete immersion must last two hours. Dufour recommends for the disinfection of graft bearers coming from a phylloxera district the steeping of these in a solution of the following: sulphocarbonate of potash 0·5 per cent; soft soap 5 per cent; pyrethra powder 1 per cent; tobacco juice 1 per cent.

Carpocapsa pomonella (*Pyrale du Pommier*) (the codlin moth); *Carpocapsa funebrana*, Fr. (? *Carcocapsa nigricane*) (the red plum grub).—Montillot recommends watering the soil at the foot of the trees in autumn, after collecting the fruit, with a solution containing 1 per cent of sulphocarbonate potassium.

Conchylis ambignella, Hubn. (cochylis of the vine).—Dufour tried to combat this insect by spraying with sulphocarbonate, but he did not kill the caterpillar. A bouillie containing 1 per cent of sulphocarbonate and 3 per cent of soap destroyed the insects but scorched the buds, which browned and finally dropped off. A 0·1-0·05 per cent solution does not injure the plant and kills all underground larvæ.

Formica (ants).—An excellent means of destroying an ant-hill consists in the use of sulphocarbonate. A small trench is dug round the ant-hill and it is watered in the morning as far as possible, when the ants have not yet gone out, with an 0·5 per cent solution. Half a litre to a litre of this solution suffices to destroy an ant-hill. After absorption of the liquid it is well to beat the earth down.

Galeruca calmariensis (galeruca of the elm); *Galeruca Alni* (galeruca of the alder). — Sulphocarbonates in solution applied in August destroy these insects so injurious to the trees in our parks and public promenades. [See p. 137.]

36. Xanthogenate of Potassium, C_2H_5OCSSK.—**Definition.**— This compound is the potassium salt of the ethylic ether of dithiocarbonic acid, OHCSSH.

Preparation.—By acting with an excess of carbon disulphide on absolute alcohol saturated with caustic potash. The crystals of xanthogenate of potassium formed abundantly are washed with ether.

Properties.—Xanthogenate or ethyl sulphocarbonate of potassium forms colourless or slightly yellowish needles; they are soluble in water, likewise dissolving in 5-6 parts of absolute alcohol. The decomposition of the aqueous solutions into carbon disulphide, ethyl alcohol, and potash begins at a temperature of 25° C. (77° F.), to be completed on boiling. Xanthogenate of potassium stops fermentation like carbon disulphide and coagulates albumen. Schwartz found that the action

of its solutions on bacteria and ferments do not commence except at the temperature at which this salt decomposes, and that it only therefore possesses the disinfectant action of carbon disulphide. But this does not in any way detract from its valuable properties as an antiseptic, since carbon disulphide acts on bacteria in aqueous solution at 0·5 per cent and that this product contains 47 per cent of carbon disulphide. In medicine xanthogenate of potassium has found different uses. Lewin recommends it against helminthiasis and for different affections of the skin.

Use.—Xanthogenate of potassium may be used in all cases where carbon disulphide and sulphocarbonate of potash have been found useful. Its solubility in water is greater than that of carbon disulphide and its stability in air more perfect than that of sulphocarbonate of potassium. Its properties would have assured it a much higher place in agricultural medicine if its price were not higher than similar compounds. Yet in spite of its high price xanthogenate of potassium is used in disinfection and enters into the composition of certain insecticides.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—Dr. Koenig, director of the Agronomical Station of Nice, has made very extended trials of the action of this salt on phylloxera, and found that compared with carbon disulphide and sulphocarbonate of potash its value as a disinfectant of phylloxera-infected vines was greater and more certain. The eggs and phylloxeras are killed without exception by submitting them to the action of solutions of xanthogenate of potassium or to that of the vapours which its solution emit on heating. To disinfect the roots Koenig recommends the use of aqueous solutions. The disinfection of ornamental plants suspected of phylloxera and intended for export is carried out at the Nice station by Koenig's process alone.

Schizoneura lanigera, Hausm. (woolly aphis).—Muhlberg recommends to combat the woolly aphis an insecticide known as knadolin, which whilst preserving the properties of Nessler's contains two most active substances, nitrobenzene and xanthogenate of potassium. Amyl alcohol 60 lb., soft soap 40 lb., nitrobenzene 2 lb., xanthogenate 1 lb., water 6 gallons. Knadolin in 2 per cent solution kills the greater number of insects injurious to plants. To apply it the wounds and cankers caused by the American woolly aphis are coated with a solution of 1 part of this insecticide in 15 parts of water.

37. Potassium Cyanide, KCN. — **Preparation.** — Potassium cyanide is formed each time that carbon and nitrogen come in contact at a high temperature with an alkali or an alkaline carbonate. Commercially potassium cyanide is prepared by submitting nitrogen or organic bodies rich in nitrogen to the action of carbon impregnated with potash and heated to redness. Prussic acid or hydrocyanic acid is generated by the action of an acid on potassium cyanide. The latter, however, does not cede all the hydrocyanic acid which it contains.

Properties.—Potassium cyanide crystallizes in deliquescent cubes; it is found in commerce as fused white plates which must be kept out

of contact with air because that decomposes it rapidly into hydrocyanic acid and carbonate of potash—

$$2KCN + H_2O + CO_2 = K_2CO_3 + 2HCN.$$

The commercial product is never pure, it always contains a greater or less amount of carbonate of potash. Prussic acid is a colourless, very volatile liquid having the odour of bitter almonds. It is, like its salts, a dreadful poison. The vapours given off by decomposition in contact with air kill the insects and animals which breathe it in a few minutes. Its action is the same in whichever way it be introduced into the body, by digestion, respiration, or introduced into the blood through a wound. A drop of hydrocyanic acid placed on the eye of a dog causes it to die in a few seconds a dreadful death. The respiration of the vapours of this acid induce giddiness, then death. The mortal dose for a man is 0·06 gramme, say 1 grain, of prussic acid and 0·15 gramme, say $2\frac{1}{4}$ grains, of potassium cyanide. According to Preyer, prussic acid acts through the compounds which it forms with the hæmoglobin and the oxyhæmoglobin of the blood.

Action on Plants.—All cyanogen compounds have a poisonous action on plants, but it is prussic acid which possesses this property in the highest degree. As far back as 1827, Goppert remarked that prussic acid prevented the germination of grain, and absorbed by the plant it killed it in one to three days. When a plant is watered with a dilute solution of cyanide the latter is absorbed and distributed throughout all parts of the plant by the sap; the leaves turn yellow, then brown, and the turgescence of the cells of the parenchyma is abolished. Perosino succeeded in injecting a very dilute solution of potassium cyanide into the trunk of a tree without hurting it, and after two days all trace of this product had disappeared in the sap, but the dose to be withstood was, it is true, infinitesimal. Berlese has shown that trees withstand these injections badly, even in small doses. Mouillefert made a very complete examination of the action of potassium cyanide on vines and adventitious plants.

Experiments made in July on Healthy Vines, variety Saint Emilion.—Placed in pots, each containing 3 litres of soil, three vine stocks were watered with (1) 170 milligrammes of cyanide, say a 0·142 per cent solution; (2) 250 milligrammes of cyanide in 140 cubic centimetres of water, say a 0·18 per cent solution; (3) 500 milligrammes of cyanide dissolved in 180 cubic centimetres of water, say a 0·28 per cent solution. In six days vine No. 3 was dead, that carrying No. 2 was greatly inconvenienced, and No. 1 seemed to suffer. As will be seen from these results the substance is highly poisonous to the vine, as a dose of 0·008 per cent of potassium cyanide in the soil kills this plant. Guerrieri estimates that a dose of 1 gramme suffices to kill an adult vine, and that it is impossible to kill the phylloxera by this method, the vine being as sensitive as the parasite. The fact that the phylloxeras of a vine treated with cyanide die mainly by the absorption of the poisoned juice, shows that this method of treatment must be as pernicious to the vine as to the phylloxera; Chittenden considers that it is impossible to treat all plants by hydrocyanic acid vapours to free

them from plant lice; the acid may, however, be used without fear on *Davallia*, *Adiantum*, *Coleus*, *Viola*, *Rosa*, *Diantus*, *Vitis*, and *Lycopersicum*. It is necessary to try each variety of plants to see if this method of treatment can be successfully adopted against the caterpillars without risk to the plants themselves.

Experiments made in July on Adventitious Plants.—The experimental ground was a square with side of 50 centimetres and contained young plants about fifteen days old (*Mercurialis annua*, *Polygonum aviculare*, *Amarantus blitum*, *Borago officinalis*, and *Erodium cicutarium*); 500 milligrammes of potassium cyanide, dissolved in 400 cubic centimetres of water, say a solution of 0·125 per cent, was distributed in five deep holes of 15-20 centimetres. In the morning all the young plants were dead. After six days nothing remained alive but two stocks of *Borago* and one stock of *Erodium*.

Action on Fungi.—Few trials have been made. Hitchcock and Carleton immersed the uredospores of *Puccinia graminis* in a 0·1 per cent and a 0·01 per cent solution. The first solution prevented germination. The second had no effect.

Action on Insects.—Potassium cyanide, also the prussic acid given off from it in moist air, are insecticides of extraordinary power, an infinitesimal dose killing insects in a few minutes. Its action is more energetic than that of sulphocarbonate of potash, sulphuretted hydrogen, and ammonia. It acts on insects by respiration and through the stomach. Entomologists use it to kill the insects which they catch. Mouillefert submitted different insects to the action of this poison, especially the phylloxera, which he specially examined. One gramme of potassium cyanide was placed in a 250 cubic centimetre flask. The following are the results obtained with the different insects introduced successively into the flask: A butterfly died in four minutes; a dragonfly in ten minutes; an earwig in ten minutes; a plant louse is annihilated in less than two minutes; a stag beetle in four minutes; and a grasshopper in less than two minutes.

In America potassium cyanide is a specific for the destruction of certain plant lice; it is to be observed, however, that their eggs withstand doses usually sufficient to kill the adult insects. According to Coquillet it is chiefly the *Diaspines*, amongst which must be counted *Aspidiotes*, *Diaspis*, *Lecanium*, *Ceroplastes*, *Cochineal*, which are most sensitive to prussic acid. Whilst almost all insects succumb when they respire a weak doze of prussic acid, there are some which are indifferent to this poisonous gas: these are certain *Coccinella*, the red spider (*Acarus telarius*) of Linneus (*Tetranchus telarius*, L.); the *Schizoneura lanigera*, Hausm. (woolly aphis); and some flies of the family of Proctotrupidæ of the genus Alaptus. The danger of the prussic acid treatment is an obstacle to its becoming general, the more so as there are less dangerous substances, which, in the same conditions, are of equal service. There are, however, certain cases where prussic acid is superior to these products. When it is a question of destroying one of those plant lice covered with a chitinous carapace, ordinary insecticides which do not reach the insect must be set aside, because they cannot reach it. Emulsions of petroleum, amyl alcohol, benzine,

and carbon disulphide, with soft soap, only yield imperfect results. It is otherwise with prussic acid; its vapours, owing to their poisonous nature, can destroy the best protected insects through the respiratory organs, and as easy as any soft-skinned insect. In America the benefits of the substance have been recognized, and it is in constant use by farmers. To-day all fruit-growers use it with success, and owing to potassium cyanide used rationally in winter, fruit trees are freed from all their parasites. In America apple-trees have been particularly the prey of the San José louse, but potassium cyanide, which has played in this case the rôle of carbon disulphide in the phylloxera invasion, has enabled this dangerous cochineal to be circumscribed and efficiently combated.

Use.—In spite of its toxicity and the danger incidental to its use, potassium cyanide is in current use in certain countries; it is, in fact, the most radical and the cheapest means to destroy tree parasites. Cyanide can only be used in a closed space. Its decomposition is hastened by the addition of dilute sulphuric acid. This practice requires great precautions, because the prussic acid given off is as deadly to the operator as to the insects. When a greenhouse is not at disposal the operation is done under cloches for small plants, and under tents for trees. The latter are of packing cloth, impregnated with linseed oil and ochre, or wax. These portable tents are generally hexagonal in shape and must touch the ground on all sides; they are closed hermetically by beating down the soil on the edges of the cloth. In America they use exclusively large cubes with a wooden framework covered with packing cloth. In this manner trees as high as 20 feet may be treated. To disinfect a tree the tent is placed over it, and then a solution of potassium cyanide is run into a terrine to which dilute sulphuric acid is added, taking care to place this terrine quickly under the tent and to retire. The following, according to Debray, are the quantities to use for 5 cubic metres of air: 30 grammes of 58 per cent potassium cyanide dissolved in 50 cubic centimetres of water, 35 grammes of sulphuric acid of 66° B. (168° Tw.) diluted with 50 cubic centimetres of water, and, according to Coquelin, the doses of potassium cyanide to use according to the size and force of the tree:—

TABLE XIX.—*Showing the Amount of Potassium of Cyanide, Water, and Sulphuric Acid to Use in Cyaniding Trees of Different Height and Diameter.*

Height.		*Diameter.*		*Potassium.*		*Water.*	*Sulphuric Acid.*	
Metres.	*Feet.*	*Metres.*	*Feet.*	*Grammes.*	*Grains.*	*c.c.*	*Grammes.*	*Oz. Av.*
3	9·84	2·50	8·20	65	997	130	65	2·3
3·50	10·48	3·00	9·84	130	1994	250	130	4·5
3·50	10·48	4·50	14·76	250	3835	500	250	8·7
4·25	13·94	3·00	9·84	160	2454	350	160	
4·25	13·94	3·50	10·48	210	3222	500	210	
4·75	15·58	4·25	13·94	340	5216	750	340	
5·50	17·08	4·25	13·94	425	6521	850	425	

The action is complete in a quarter of an hour (Dubray), three-quarters of an hour (Ritzema Bos), and five hours to destroy kermes (Reh). Johnson says that disinfection is complete in a very short time, and that with ten apparatus, 200 trees may be disinfected in a day, the operation lasting half an hour. A method much in vogue in America consists in disinfecting the roots of young nursery plants as far as the crown. For this purpose all the trees are dug up, and placed in closed cupboards or chambers in which prussic acid is disengaged; 10,000 young trees can be disinfected in this way at a time. Dr. Koenig has introduced the practice of this style of disinfection at the Agronomical Station of Nice, where it is employed for vines, ornamental plants, as well as the branches of ornamental plants intended for exportation. Waite and Howard recommend for the disinfection of purchased trees hermetically sealed cupboards, in which they are enclosed for an hour in an atmosphere of prussic acid before replanting; although the majority of plants resist the action of these poisonous vapours it is preferable to operate during the repose of vegetation, for in that condition they resist stronger doses capable of destroying the parasites and their eggs. The action may be prolonged, and even last an hour. The result is only the more complete. Tuille recommends for the destruction of the larvæ of the cockchafer (*Melolontha vulgaris*, L.) to plough in colza or mustard during the flowering season along with a ton of gypsum or lime per hectare (8 cwt. per acre). Amongst the poisonous gases given off in consequence of the fermentation of these plants is sulphuretted hydrogen, but also a certain amount of prussic acid.

Scolytides.—In America prussic acid is regarded as an excellent substance for destroying the insects which dig galleries in the trunks of trees. It may be applied at the moment the *Scolytides* or the *Bostriches* attack the young trees.

Wasps.—Gardner recommends the use of a solution of 120 grammes in a litre of water (1·2 lb. per gal.). A plug of waste is attached to a rod dipped in this solution, then introduced into the orifice of the nest of wasps. The effect is instantaneous.

Nematus Ribesii, Scop. (gooseberry saw-fly).—The highly voracious larvæ of this saw-fly are destroyed in Canada by cyaniding, working under small tents as already mentioned. The gas acts in fifteen minutes. To destroy the butterflies injurious to cotton plantations, Mally plants haricot beans between the rows. As soon as the latter are in flower they are sprayed with a dilute solution of potassium cyanide. That kills the butterflies which settle on the flowers.

Carpocapsa pomonella (the codlin moth).—It is in winter that fumigation under a tent with prussic acid may be very effectual. The process is in common use in Canada.

Diplosis violicola, Coquillet (violet fly).—Chittenden advises treating the violet stocks with potassium cyanide, so as to kill the larvæ of this fly.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—*Experiments on the phylloxera action by contact.*—A phylloxera-infected root was immersed for two minutes in a 1 per cent solution of potassium

cyanide ; the phylloxeras and their eggs were all dead when it was lifted out.

Experiments on Phylloxera : Fumigation.—Five milligrammes of potassium cyanide, yielding by decomposition 1·7 cubic centimetres of prussic acid vapour, were placed in a flask of 2100 cubic centimetres, then a phylloxera-infected root. When the action was complete the atmosphere of the flask consisted of 8 parts of prussic acid vapour per 10,000 parts of air. After fifteen hours there were no living insects. It follows that potassium cyanide is about ten times more poisonous than potassium sulphocarbonate, for it suffices for an atmosphere to contain 0·08 per cent prussic acid gas to obtain the same result as with 0·75 of a mixture of equal parts of sulphuretted hydrogen and carbon disulphide, disengaged from potassium sulphocarbonate. Under a cloche 0·000240 of potassium cyanide kills plant lice.

Experiments on Phylloxera : Action by Poisoning.—A phylloxera-infested root was immersed by its extremities in a 0·125 per cent solution of potassium cyanide with the precautions necessary to hinder the phylloxera being exposed to prussic acid vapours. After ten minutes' treatment the adult phylloxera, the nests of which were sunk in the tissues of the root, were dead, the greater number of the larvæ were alive. The cyanide can thus poison the sap, and in that way reach the phylloxeras fixed on the roots. Mouillefert having shown that potassium cyanide acted in a very poisonous manner on the phylloxera, and that an infinite quantity killed these insects either by contact or by poisoning the sap, the substance may be regarded as of great service in agriculture.

1. *Experiments on Phylloxera-infected Vines,* in pots containing 3 litres of earth, on 10 July. A dose of 150 milligrammes of KCy in 400 cubic centimetres of water (a 0·0375 per cent solution) gave a complete result without injuring the vine, whilst a dose of 500 milligrammes in 500 cubic centimetres water caused it to suffer greatly. A dose of 1 gramme in the same amount of water killed it.

2. *Experiments on Vines in Vineyards,* made on 6 July. The stocks were stripped to a depth of about 15 centimetres, with a radius of 30-35 centimetres (12-14 inches), the soil being rather dry. After pouring on the potassium cyanide solution the soil was replaced at the foot of the stocks and strongly packed. The dose used varied from 20-50 grammes (307-767 grains) per stock, dissolved in 10 litres (2·2 gallons) of water. Wherever the solution had penetrated, the phylloxera and their eggs were dead. But at a depth of 40-45 centimetres (16-18 inches), as well as between the stocks in a radial direction, even by using five times more water the result was incomplete. Trials with the pal-hole method gave no better results, and Mouillefert concluded that potassium cyanide was incapable of producing a complete result in agriculture on the large scale, because its action is only felt where the solution can penetrate. The prussic acid disengaged in the soil cannot diffuse through its layers like carbon disulphide, neither does F. Guerreri believe it possible to use this substance against the phylloxera, for he found that the plant did not resist the doses required

to kill it, and that a dose of 1 gramme of cyanide, say 15 grains, per stock was capable of injuring it. Attempts to replace carbon disulphide by potassium cyanide, more especially in Italy, have given unfavourable results.

Disinfection of the Vine.—Whilst potassium cyanide has been abandoned in the different cases described above, this product is used with success to disinfect vines intended for exportation, or coming from a contaminated country. This process, introduced at the Nice Agronomical Station by Koenig, yields perfect results. It is in common use, moreover, in Tuscany. Sannino advises to replace the disinfectant chambers by baths containing a 0·5 per cent solution, and in which the vines are immersed in winter for two hours. The same process is used to destroy cochineal on fruit trees.

Diaspines (*Diaspineæ*).—Coquillet uses prussic acid as a specific against *diaspineæ*, cochineals (scale insects).

This product may be used against all these dangerous parasites, of which the following are the chief: *Aspidiotus perniciosus*, Comstock (San José louse), injurious to apple-trees in America. *Aspidiotus ostreaformis*, Curtis. Oyster scale, very widely distributed on apple-trees, plum-trees, pear-trees, and peach-trees. *Aspidiotus aurantii*, Maskell. Cochineal injurious to orange-trees. *Diaspis ostreaformis, sign. s. fallax*, Horvath. Cochineal injurious to apple, pear, plum, and peach trees. *Mytilaspis pomorum*, Beché. Mussel scale, resembling the preceding and living on same plants. *Lecanium persicæ* (peach kermes); *Lecanium hesperidium* (olive kermes); *Pulvinaria vitis* (vine cochineal); *Cereplastes rusci* (fig cochineal); *Dactylopius citri* (lemon-tree cochineal); *Lecanium amygdali* (almond-tree cochineal). Coquillet, Johnson, Webber, Wait, and Howard, American entomologists, are unanimous in praising the good effects of the use of potassium cyanide, and that insecticide is in current use in their country. So that the result may be complete, the treatment should last three-quarters of an hour, and the operation done in winter as indicated above.

Earth-worms are less resistant than plants to spraying with a dilute solution of potassium cyanide and they may be got rid of by this means.

38. Potassium Sulphocyanide, KCNS.—**Preparation.**—Sulphocyanides are produced by the action of sulphur, or a body capable of producing sulphur, on cyanides. Potassium cyanide, or even yellow prussiate, fused with sulphur is converted into potassium sulphocyanide thus: 46 grammes of yellow prussiate are heated to pasty fusion with 17 grammes of potash and 32 grammes of sulphur; after cooling, the mass is crushed, treated with boiling alcohol, filtered, and evaporated.

Properties.—If sulphocyanide has certain analogies with cyanide it is far from being as poisonous. It paralyses the action of the heart (Cl. Bernard and Pelikan).

Action on Plants. — Mouillefert treated several plants with KCNS:—

(1) *Experiments on Adventitious Plant Weeds.*—In a space 16 inches square on which there were young plants of *Mercurialis annua*, *Amarantus blitum*, *Senecio vulgaris*, *Sonchus oleraceus*, *Polygonum*

aviculare, Mouillefert placed in six holes, 6 grammes, say 91 grains, of KCNS, dissolved in a litre of water (6 parts in 1000). Next morning all the young plants were dead. The adult plants had suffered greatly.

(2) *Experiments on Healthy Vines in Pot.*—Half a gramme of KCNS in 250 cubic centimetres water (1 in 500) and spread round the stock killed it in five days. KCNS thus has a very injurious action on plants, an action almost equal to potassium cyanide. As it does not act by its vapours, its action on the plant depends solely on the permeability of the soil for its solutions. This explains why equal doses do not always produce identical effects. The same applies to aqueous solutions of all stable salts. Kranch treated barley with $(NH_4)CNS$, and found that a 1 per cent solution killed this plant.

Action on Fungi.—Sulphocyanides do not act like cyanides (Hitchcock and Carleton). A 1 per cent solution used in immersion for twenty-four hours did not prevent the uredospores of *Puccinia coronata* from germinating.

Action on Insects.—Mouillefert treated phylloxera-infected vines with a dilute solution of KCNS. An infected pot plant was watered with the dose recognized as capable of killing the vine, say 0·5 gramme, dissolved in 250 cubic centimetres of water. Whilst the vine was poisoned the phylloxera were uninjured. Sulphocyanide, very energetic on plants, is thus with the same dose without action on the phylloxera and cannot thus be used against it.

Addendum to Chapter VII., p. 129—being omission from Section 35, Potassium Sulphocarbonate :—

Tipula Oleracea (meadow tipula).—To destroy the larvæ of tipula, carbon disulphide may be replaced by spraying meadows and fields with a dilute solution of potassium sulphocarbonate. Barthon, who recommends this treatment, advises to test previously the dose which will not injure the plants on which it is to be applied. A solution of 0·1 to 0·5 per cent never injures plants and kills all underground larvæ.

CHAPTER VIII.

BARIUM CHLORIDE — BARIUM SULPHATE — BARIUM CARBONATE—BARIUM SULPHOCARBONATE—CALCIUM OXIDE (QUICKLIME)—CALCIUM SULPHIDE—CALCIUM CHLORIDE—CALCIUM CHLORO-HYPOCHLORITE (BLEACHING POWDER)—CALCIUM SULPHATE (GYPSUM PLASTER OF PARIS)—CALCIUM SULPHITE—CALCIUM CARBIDE—CALCIUM PHOSPHIDE—CALCIUM ARSENITE.

39. Barium Chloride, $BaCl_2$. — **Preparation.** — By treating barium carbonate (Witherite) with dilute hydrochloric acid. Carbonic acid is given off and barium chloride crystallized as small rhomboidal lamella formed with two molecules of water of crystallization.

Properties.—Barium chloride is soluble in water; 10 gallons of water dissolve 45 lb. at 15° C. Its taste is sharp. It is so poisonous that 4-5 grammes, say 60-75 grains, according to Parkes, kill a man, on whom it first induces general weakness, then paralysis.

Action of Barium Chloride on Plants.—When plants are watered with barium chloride in 0·05-0·5 per cent solution, chlorosis is induced and lesions occur on the roots. This action is more pronounced the younger the plant, and likewise varies with the nature of the plant. Barium chloride behaves like common salt and like carbonate of lime.

Action on Insects.—It appears to be very poisonous to insects. Absorbed with food this salt kills them as rapidly as arsenical preparations.

Use against Plant Diseases.—Maravek recommends 2 per cent solutions to kill injurious insects. G. Staes uses it with success against the ravagers of young beets, and especially against the altises which sometimes completely devour the young leaves. Young plants support a few days after sprouting a 2 per cent solution of $BaCl_2$, and when in leaf a 3 per cent solution. Three sprayings kill coleopterous parasites. Mokezecki recommends spraying with $BaCl_2$ to destroy the grub of the following ravagers: *Anisopterix æscularia*, Schiff.; *Hibernia marginaria*, Bk.; *H. defoliaria*, *Cheimatobia brumata*, L.; *Uropus ulmi*, *Himera pennaria*, *Phlacetonodes sticticalis*, and *Hyponomeuta malinella*, Zell. They recommend the use of this salt according to circumstances in 1½ to 2-3 per cent solution, adding 12 per cent of sodium carbonate to give adherence to the liquor by the resulting barium carbonate. The action of this product on the grubs makes itself felt after four hours, whilst emerald green under similar conditions requires twenty-four hours to act. This poison, very violent to grubs and insects, would appear to be harmless to the plants treated, for neither the leaves nor the fruit appear to suffer in contact. It is, however, costly and very

poisonous; it must, therefore, be used with great caution, especially on meadows used as pasture for domestic animals.

Weevils.—Still recommends $BaCl_2$ to kill them.

Peritelus griseus (vine weevil).—Štromer remarks its presence on the hop, and recommends spraying with $BaCl_2$ solutions to kill it.

Phorodon humili, Schrank (hop aphis green-fly).—Metzger kills this louse by spraying with 1 per cent solutions of $BaCl_2$. The results obtained have been very satisfactory, and he regards this salt as more efficacious than Dufour's insecticide, and extracts of quassia. As aqueous solutions of $BaCl_2$ want adhesiveness, Metzger recommends a paste of 2 per cent of barium chloride and 1·5 per cent of soft soap. Eight days after treatment the aphides had entirely disappeared.

Rodents.—Barium chloride acts on rodents like carbonate of baryta. To exterminate them radically Hilner places bread dipped in barium chloride in their runs.

40. **Barium Sulphate**, $BaSO_4$.—Passerini found that pastes made with barium sulphate had no action on *Peronospora viticola*, De By.

41. **Barium Carbonate**, $BaCO_3$.—**Preparation.**—By precipitating solutions of barium chloride by carbonate of soda. The natural carbonate (Witherite) is not used as such.

Properties.—Poisonous, insoluble in water.

Use.—Largely as poison for the rodents which ravage cultivated land. One pound of bread is mixed with $\frac{3}{4}$ oz. of sugar and $\frac{1}{4}$ lb. of precipitated carbonate of baryta; the mass is kneaded and then divided into about 2000 pills (Ressler). One lb. of barley meal is kneaded with $\frac{1}{4}$ lb. carbonate of baryta and the amount of water necessary to make a stiff paste and divided into pills and laid in their runs (Crampe).

42. **Barium Sulphocarbonate**, $BaCS_3$. — **Preparation.** — By treating a concentrated solution of barium monosulphide by carbon disulphide, solid barium sulphocarbonate is deposited.

Properties.—Barium sulphocarbonate is a yellow salt slightly soluble in water and resists the action of the carbonic acid of the air for some time; it is more stable than alkaline sulphocarbonates, but it is equally poisonous to plants, and has equal powers as an insecticide.

Use.—*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Mouillefert examined its effect compared with alkaline sulphocarbonates. Two vines were stripped down to the large roots and treated with 75 grammes ($2\frac{1}{2}$ oz.) of barium sulphocarbonate; the first was not watered in any way, whilst the second was immediately watered with 6·5 litres of water, say $1\frac{1}{2}$ gallons. With the latter the result was perfect, whilst on the roots of the first a large number of undestroyed parasites were found. Barium sulphocarbonate exists a long time in the soil without decomposition, and if not dissolved by heavy rain its action is too slow, and is not transmitted to the deep roots. The latter are not therefore surrounded by a sufficiently poisonous atmosphere to kill the phylloxera and the results are bad.

43. **Calcium Oxide (Quicklime)**, CaO.—**Occurrence.**—Widely in nature; chiefly as carbonate, sulphate, silicate, and phosphate of lime.

Preparation.—Quicklime may be made from carbonate of lime, either in the pure state as marble or chalk, or impure as marl or limestone. Limestone is burnt in lime kilns by heating it gradually to a red heat. This heat, kept up for three days on an average, decomposes the limestone into quicklime and carbonic acid.

$$CaCO_3 = CaO + CO_2.$$

As soon as the burning is finished and the mass cooled, it is packed in casks, and hermetically sealed so that the air does not affect it by its carbonic acid and moisture.

Properties.—Lime is converted by the action of water into hydrate of lime ($CaOH_2$) or slaked lime. In slaking, the lime gives off much heat and swells or increases in bulk. In contact with carbonic acid calcium hydrate is converted into calcium carbonate ($CaCO_3$). Milk of lime exposed to the air does not keep more than two to three months, and gradually loses its caustic properties. Lime is very slightly soluble in water, which only dissolves at the ordinary temperature 0·14 per cent; hot water only dissolves 0·1 per cent. Lime stirred up with water remains suspended, and forms a milky liquid, "milk of lime". This milk is the fatter the more pure the lime from which it is made. There are two sorts of lime, fat lime and thin lime. The first comes from the burning of almost pure limestone, such as chalk or marble; it is white, and gives off much heat on slaking and increases two to three times in bulk; it forms with water a fatty and binding paste. Thin lime, on the other hand, is produced by the impure limestones referred to above; it is grey, and disengages little heat on slaking; mixed with water it hardly swells and forms a short paste. For agricultural purposes, and particularly for agricultural medicine, it is necessary to choose a fat lime, which yields on slaking a very caustic impalpable powder, which, stirred up with water, yields a milk with great adherence. To increase this still more, a little cement, bullocks' blood, potters' clay, or cow dung is added. The white colour, often too glaring, is subdued by stirring in a little lampblack into the milk of lime.

Use of Lime as Manure.—Lime is necessary to plants. Crystals of oxalate and carbonate of lime exist in the cell-walls to which they impart rigidity. In its absence farm crops languish, young plants stop growing, the roots die. Liming the soil has for a long time been largely applied, for lime spread on the soil, especially on heavy ground, produces heavier crops of potatoes, peas, beans, tares, clover, lucerne, etc. Moreover, lime destroys the noxious weeds, which require a soil poor in or almost deprived of lime and sometimes even acid. The rôle played by lime in the practice of farming may be explained thus: When lime is applied to the land it neutralizes the acidity of the soil, chiefly humic acid, which it converts into humate of lime; the ferments in the soil which do not work in acid lands then develop in the slightly alkaline medium created by the lime; the organic matter is disintegrated and decomposed; its nitrogen is converted first into ammonia and then into nitric acid, the presence of which is necessary to the nutrition of cultivated plants. Lime by rendering the nitrogen

contained in humus assimilable by plants thus modifies the flora and the yield of cultivated land; plants of poor nutritive value, such as mosses, heather, reeds, and rushes, disappear, whilst delicate meadow plants—leguminosæ and gramineæ—are greatly developed. A peaty soil after liming is rapidly converted into arable land. But if liming is a very desirable operation it is very exhaustive to the soil. The organic matter which forms a nitrogenous reserve for the plant rapidly disappears under its action. Fresh reserves must therefore be brought on to the land, as farmyard dung, if regular and satisfactory yields are to be obtained. Soils deficient in lime are generally poor in phosphoric acid; thus liming should be accompanied by phosphatic manures, for the effect of lime would not be perfect if any element necessary to the plant was deficient in the soil. Besides lime not only decomposes the humus, it transforms certain minerals rich in fertilizing elements; the clays which contain potash, for example, are converted into double silicates of alumina and lime and soluble potash. At the same time the lime acts on the neutral sulphates in chemical manures, fixing the sulphuric acid and bringing the nutritive elements into a more assimilable form, such as sulphate of iron, sulphate of potash, sulphate of ammonia. Lime greatly modifies the soil with which it is incorporated, it gives strength to light land because the humate of lime agglutinates the earthy particles together; strong soils are rendered more friable and wet soils sufficiently dry. Yet all the benefits of liming disappear if used in too great amount. Viala found by trials on the vine that lime in excess produced symptoms of chlorosis whilst small amounts applied gradually yield a luxurious vegetation.

Muntz and Girard find it more preferable to apply lime in small doses every three years than to apply large quantities at longer intervals. The amount of lime to apply varies with the composition of the soil and its depth. Liming should always be done in autumn. A soil to be fertile should contain a minimum of 3 per cent of carbonate of lime and even 5 per cent in clay soils. On granite soils it is necessary to apply 10-12 hectolitres of lime per hectare (11-13·2 bushels per acre), whilst on soils rich in organic matter 20-24 hectolitres (22-26·4 bushels per acre) must be applied. Friable soils only require 15 hectolitres ($16\frac{1}{4}$ bushels per acre), heavy soils 20-30 hectolitres (11-33 bushels per acre), and peaty soils 35 hectolitres ($38\frac{1}{2}$ bushels per acre). The following is the method to pursue in liming land: The quicklime is laid down directly on the fields in heaps of 20-50 litres (4·4-11 gallons) and the heaps covered with a layer of soil. In three weeks the lime is completely converted into hydrate. The lime is then spread uniformly over the ground and then harrowed into the soil so as to mix it intimately therewith. This method is the simplest and quickest. A manure rich in nitrogen and in lime is made by slaking lime in composts where the lime is mixed with farmyard dung, organic matter, farm waste, etc. Three weeks afterwards the whole is covered with earth. If watered frequently slaking is finished in a few months, and the lime so obtained may be spread on the land and mixed with the soil.

Action on Plants.—Milk of lime is a strongly alkaline product

which behaves to plants like alkaline liquids, that is to say, it injures the young buds but is without action on the adult organs. Cellulose is not attacked by lime, so milk of lime may be used with impunity in spraying on the different parts of adult plants, and the strength of this milk of lime may be increased at will. There are, however, some exceptions. Sorrel, for example, does not stand its action; the same applies to mosses and lichens, the growth of which requires much moisture, are quickly destroyed by lime and especially by quick-lime.

Use against Fungi.—Alkaline substances have a decided but weak action on fungi spores. This property was utilized in the beginning of last century to destroy the spores of smut and bunt; at that time no substance fit to render the same service was yet known, and lime was officially recommended by the (French) Government although it had not given very complete results. The chief advantage was that the method did not injure the seed. However, Phillipar found that after this process had been applied, and although all the grains were uniformly covered with lime, the resultant crops still gave 260 bad ears per 1000. Girardin likewise found 112 bad ears per 1000 after macerating the seeds for twenty-four hours in 1 per cent milk of lime. Loverdo believes that this bad result is due to the cellulose nature of the exospore of the *Ustilagineæ* which opposes a resistance to the alkaline action of lime. According to tests by Kuhn the spores of the bunt of wheat, *Tilletia Caries*, resist milk of lime for five hours, but after twelve hours' immersion they have lost their vitality. Bolley does not believe in lime as a disinfectant. Slaked lime in powder had no appreciable action, but immersion for twenty-four hours in a milk of lime gave a result especially on addition of a certain amount of common salt. The following, according to Mathieu de Dombasle, is the comparative result of this treatment, bad ears in 1000 carried out in various ways: Blank wheat, 486. Wheat covered with lime powder, 476. Wheat moistened with milk of lime, 260. Wheat immersed for twenty-four hours in milk of lime, 21. Wheat immersed for twenty-four hours in milk of lime of 2·5 per cent strength and 4 per cent common salt, 2. The effect of lime is thus very perceptible, but as soon as common salt or sulphate of soda is added the effects are much more perfect. Lime is not now used alone to disinfect cereal grains, but is an indispensable aid to this treatment. Its chief rôle is to neutralize the disastrous effects of the poisonous salts on the germinative capacity of the seed and to fix the anticryptogamic products in an insoluble form on the surface of the seeds. By treating with milk of lime seeds which have been steeped in a solution of blue vitriol, the action of which is very injurious to the vitality of the seeds, this salt is converted into copper hydrate. The latter mixed with sulphate of lime forms round the grains a deposit of preservative matter, so little soluble as not to be washed away by the water in the soil and capable of preventing the germination of the spores adherent to the surface of the grain as well as the invasion of filaments of bunt which might be present in the soil. In America attempts have been made to disinfect seed corn by a mixture of milk of lime and a

·5 per cent solution of soap. But the results were unsatisfactory. The spores of *Phytophthora infestans*, De By. (potato disease) resist milk of lime; the latter is incapable of arresting the development of that disease. Rust of wheat likewise resists the action of lime even in heavy doses and in mixing it with equal parts of sulphur.

Hitchcock and Carleton have, however, found that lime paralysed the growth of the uredospores of *Puccinia Rubigo vera*, Wint. (rust of wheat). But lime has no effect on *Hypomyces perniciosus*, Magnus, mole disease of the mushroom. Used to combat the *Guignardia Bidwellii*, Viala et Ravaz (black rot of the vine), lime gives fairly good results. Galloway obtained by this method an appreciable diminution of bad seed: on the untreated plot 45 per cent of diseased seed, on the limed plot only 20 per cent of damaged grain. Debray also regards the liming of the vine as a cure for *Gleosporium ampelophagum*, Sacc. (grape rot), *Botrytis cinerea*, Pers. (the noble or grey rot of the vine). Sorauer advises to spread quicklime on the grapes in autumn as soon as this mould appears.

Gummosis of Stone Fruit Trees.—Sorauer advises to lime the ground strongly around the trees attacked by this disease so as to render the soil drier and warmer, an essential condition in counteracting this disease. Wiesner regards this diseased condition of the trees as due to the development of a special ferment, a species of diastase. Be that as it may, a good result is obtained by spreading lime in the autumn at the foot of the trees. If the trees in a moist soil suffer from canker or rot of the roots, the roots must be stripped, lime spread between them and the soil drained. This treatment leads to a perceptible improvement in the diseased condition of the tree.

Rhizoctinia violacea, Tul. (rhyzoctinia of the beet).—Frankel recommends to spread slaked lime in powder on the fields to diminish the number of parasites. Here again lime only acts directly as on mushrooms by changing the conditions favourable to their development; it arrests their growth and imparts to the plant by converting the humus into assimilable matter the capacity to resist disease better. Unfortunately it is alleged that lime, whilst it diminishes the amount of these parasites, favours the development of other and not less formidable beet diseases, e.g. *Phoma tabifica*, Prill. and Dela. (disease of the petioles of beet leaves). The alkalinity of the medium in a wet soil exerts a generally favourable influence on the development of the bacterian diseases of plants. Wheeler, Tower, Tucker, and Sorauer regard lime as favouring potato scab considerably. To reduce these diseases it is on the contrary useful to render the medium acid, say by green vitriol or by "sulpharine," which contains 15 per cent sulphuric acid.

Ophiobolus graminis, Sacc. (*Pietin*), (disease of wheat stalk).—Sance advises as a cure to sow by hand 176 lb. of quicklime per acre as soon as the disease appears. Marenghi recommends quicklime as a preventive; he advises to spread 3-4 cwt. per acre and to harrow the ground slightly afterwards.

Tobacco Leaf Spot.—Van Os to prevent this disease ploughs in 11 bushels of quicklime per acre. He thus brought down the

diseased plants to 7 per cent, whereas it was 100 per cent in the unlimed plot.

Plasmodiophora Brassicæ, Woronine (finger and toe).—Lime is an excellent means of preventing the spread of this fungus. Nijpels advises to mix the infected soil with half a litre of lime per square metre. Seltensperger applies the following treatment: During and after transplanting there is deposited at the foot of each cabbage in a sort of deep cup, of 6-10 centimetres, made for the purpose, a big handful of quicklime which is covered with earth to the level of the surface. Of 600 cabbages and cauliflowers treated thus none were attacked by the disease, whilst the untreated plot was seriously compromised; 25 per cent of the cauliflowers and 50 per cent of the cabbages were attacked. Halstead who advises this treatment in America believes that it has a preferable effect on plants to that of bouillie bordelaise, corrosive sublimate, blue vitriol, kainite, but it is necessary to use at least 2 tons 8 cwt. per acre.

Use of Lime against Nematodes.—Lime in strong doses is a cure for these worms. Lime spread on the surface of the soil changes its characters entirely. The humus (mould) sought after by these worms being transformed the soil does not any longer present the conditions essential to their growth. The evolution of the nematodes is, moreover, arrested by the alkalinity of the soil. Although lime, and especially quicklime, may disinfect the soil and thus improve certain crops it cannot replace carbon disulphide, which according to Girard destroys more surely all the nematodes in a field.

Heterodera Schachtii, A. Schmidt (nematode of the beet).—Hollrung found this nematode very sensitive to the action of lime, and that by mixing 1 part of quicklime with 4-6 parts of soil these nematodes were destroyed. Kuhn advises to apply the lime in autumn, as in that way whilst diminishing the number of nematodes the lime transforms the humus into assimilable matters and enables the more vigorous beet to reconstitute its radicular system attacked by the parasite.

Tylenchus devastatrix, Kuhn.—The liming of seed-corn is without effect against these, and disinfection does not diminish this disease as the insects are polyphagous and even saprophytic. These insects live on the most diverse plants, causing very different diseases, chiefly on onions, clover, potatoes, poppies, etc. Weiss advises to burn the stems after harvest and dust the fields with quicklime and apply mineral manure in abundance in the springtime.

Use against Insects.—Few insects are sensitive to the alkaline action of lime, yet those with soft skins and delicate larvæ do no resist milk of lime or powdered quicklime, which they particularly dread. Lime thus forms an excellent medium for fighting these parasites. But in most cases lime has only a mechanical action on the spot occupied by the insect.

Perroncito's experiments on the eggs of *Bombyx Mori*, L., have proved that milk of lime cannot kill the latter, for the eggs of this bombyx are capable of being perfectly hatched after steeping in milk of lime for twenty-four hours. In spite of this harmlessness milk of lime is used in arboriculture, for the liming of the trunks is an ex-

cellent method of diminishing the number of these parasites. The previous cleaning of the trunks removes all moss, lichens, and bark which formed so many refuges in which the insects and their larvæ pass the winter and lay their eggs. It plays as great a rôle as the liming itself. All the hiding-places preferred by these parasites are destroyed, and not knowing where to deposit their progeny they are obliged to seek refuge elsewhere. Against cochineals lime exerts a special mechanical action; their shell, covered by a thick layer of lime, is, owing to the contraction of the lime, detached from the branch on which it was fixed, thus causing its death.

Liming of Trees.—This practice advised by Blanchère is a very good one for it frees the trees well from parasites. The strength of the milk of lime may be increased to a thick paste without injuring the tree. To secure good disinfection it is better not to use milk of lime alone but mixed with tar and naphthalene as advised by Balbiani. To complete the work of liming it is well to collect and burn all the broken particles of bark and to bury with quicklime all the fallen fruit. As it slakes the lime destroys the parasites by the heat given off. By this means the number of anthonomes, cheimatobias, and even schizoneura lanigera (woolly aphis) are greatly diminished. The results will be more complete the more regularly the liming is repeated.

Scolytides.—The Bostrichi and the Hylesini, injurious to conifers, the scolytides, injurious to deciduous forest trees, cannot be destroyed by liming the trunk, but regular whitewashing with lime may remove them. Again whitewashing with thick and pliant lime in autumn after scraping the tree stops the exit orifice of the scolytides and renders the bark less accessible to the female in winter. Robert advises summer liming. If during summer a tree is badly infested by these insects there must be no hesitation in making longitudinal cuts or a surface barking, taking care immediately afterwards to coat the wound or the trunk with milk of lime. But when the tree is too far gone it is preferable to fell it and burn it, taking care to protect all the adjacent trees by liming or with the coating described further on. This operation, extensively applied in Austria, consists in painting the trunks and even the branches with a mortar made thus: Macerate 5½ lb. of tobacco in 1·1 gallons of hot water kept at a rather high heat, add 11 lb. of ox blood, and 11 lb. of lime and cow dung to a pasty consistency. The trunks and branches are coated several times with this composition until a hard weather-resisting coat is formed.

Amongst the better-known scolytides there may be quoted *Eccoptogaster Pruni*, Ratz. (scolytus of the plum). *E. regulosus*, Koch. (rugose scolytus). *E. Scolytus*, Ratz. (elm scolytus). *Hylesinus oliperda* (hylesinus of the olive-tree, cirai, taragnon). *Tomicus Ficus*, Er. (bostrich of the fig). *Tomicus Mori*, Aub. (bostrich of the mulberry). *Bostrichus dispar* (apple bark beetle), Hllw., and *B. saxesini*, Ratz., both injurious to fruit trees. All these scolytides may be removed by the above treatment.

Colaspidema atrum, Ol. (negril).—Debray recommends liming of lucerne the moment the young larvæ commence their inevitable invasion, but so as not to be forced to lime all the field of lucerne it is well to

mow it prematurely and only leave a small strip of lucerne where all the larvæ will take refuge; this strip is then limed.

Anthonomus Piri, Boh. (anthonome of the pear); *A. Pomorum* (apple blossom weevil).—Poubelle limes the trees in autumn with a mixture of lime 22-33 lb., flowers of sulphur 22 lb., gelatine 6·6 lb., the whole mixed with water to a thick paste which is spread on the trunks after removing the moss.

Haltica Ampelophaga, Geur. (altise of the vine).—The green altise which ravages the leaves of the vine may be destroyed by projecting powdered lime on to the vines (Audibert).

Crioceris Asparagi, L. (asparagus beetle).—Vial advises to dust the asparagus with impalpable slaked lime preferably in the morning dew.

Melolontha vulgaris, L.—Webster tried to destroy the larvæ of the cockchafer in fields by utilizing the heat given off by lime in slaking. Trials made in a field infected with white-worm did not give good results. Ritzema Bos also tried, but without success, to destroy insects injurious to forests, e.g. *Lophyrus Pini, L. similis, Trachea piniperda, Gastropacha Pini*, by spreading on the soil of the forests a large amount of quicklime.

Agriotes Lineatus, L.—If lime is not directly injurious to the larvæ of this insect spread on the fields, it helps greatly to diminish their numbers. According to Schilling annual liming yields still more complete results. This improvement is due to the transformation effected by the lime on the soil, which after having been wet and charged with humus favourable to the evolution of the larvæ becomes drier after liming and unfit for their development.

Gryllotalpa vulgaris (mole cricket).—In Italy this orthoptera is removed by liming at the rate of 16 cwt. to the acre.

The larvæ of some Hymenoptera are very sensitive to lime.

Nematus ventricosus, Kl., *N. Ribis*, Scop. (the gooseberry and current saw-fly).—Lime in itself forms a good means of destroying their larvæ. Firor, however, prefers a mixture of 4·4 lb. of lime and 2·2 lb. of powdered tobacco which he spreads on the shrub after moistening it.

Selandria (*Eriocampa*) *adumbrata*, Kl. (slimy caterpillar, slimy larvæ of pear saw-fly).—Lime forms an excellent means of destroying this sticky larva which skeletonizes the leaves of the pear.

Amongst the Lepidoptera a few may also be combated by lime. The large white garden butterflies are destroyed by dusting freshly slaked lime on plants and then watering them (Vial).

Cheimatobia brumata, L. (the winter moth, Evesham moth), *Sesia myopiformis*, Bkl. (sesia of the pear), *Grapholita Weberiana*, W. V.—The liming of the trunks prevents the females of these butterflies from depositing their eggs. The caterpillars of the last two butterflies may be destroyed by plastering the trees with a thick milk of lime mixed with clay (Taschenberg) and applied at the time the caterpillar is making its ravages.

Tingis piri.—This *Hemiptera* has been successfully combated by lime, which ought to be applied as a whitewash in February.

The *Homoptera* have likewise been fought by lime with more or less success, for here again it is still by its desiccating properties that it especially acts. By using milk of lime as thick and hot as possible the contraction of the lime detaches the cochineals and kills them at the same time. But a good result is not obtained unless care is taken to prune the tree and clean it from top to bottom. Thus cleansed and covered with a layer of lime the tree is not attacked by cochineals, and the fumagine (fruit tree smut) which only lives on the dejections of these insects is avoided. Liming is thus an indispensable operation in arboriculture and it gives good results if renewed each year.

Coccus Vitis, L. (red cochineal of the vine, vine scab).—Winter is the best time to attack cochineals, for that is the time that these insects get on to the trunks to lay their eggs. Bellot des Minières advises after pruning to clean the trunk completely, including scraping and careful barking. It is then whitewashed with lime which protects it against these insects.

Aspidiotus perniciosus, Comstock (San José louse).—To combat this cochineal the Americans replace lime by a mixture of salt, sulphur, and lime, sold as "salt lime and sulphur wash". Applied in winter on the trunks of trees this mixture forms a hard crust which prevents the reproduction of this insect.

Schizoneura lanigera, Hausmann (woolly aphis).—Muller advises to coat the ulcerated spots infested by this aphis with milk of lime after having completely cleaned them. To destroy the woolly aphis, which live underground around the stock and the roots, Goethe advises to strip the trees in autumn or winter to a depth of 2 feet, and water them copiously with milk of lime. A layer is then made 3 centimetres, say 1·2 inches, thick of quicklime, then the earth is covered in. Taschenberg finds this method very efficacious. To combat *green lice*, Arbrinjer advises to lime the whole tree in winter or spring. If an insecticide be added to the lime, such as tar or naphthalene, success is complete, for in that case the eggs of the louse are killed at the same time as those of the most diverse insects. Balbiani's mixture as well as milk of lime are incapable of preventing the opening of the buds, which are thus protected against insect attacks.

Limaces (snails) are also killed by lime. If it is a case of destroying snails on plants, freshly slaked lime is blown on to them from a bellows. Each snail touched dies forthwith. The best time for this operation is early in the morning, or in the evening a little after fall of day. In vineyards, the buds are protected against small snails by spreading slaked lime in powder on the stock, and laying a train of lime, 7-8 inches, around each stock. In the fields, lime is sown by hand at the rate of 25-30 bushels of slaked lime per acre. In destroying snails lime spread as an impalpable powder gives the best results. The operation is repeated several times if it is desired to reach all the snails. Lime used against snails tends to be replaced by nitrate of soda, tobacco powder, but especially by a 3-4 per cent solution of blue vitriol. This solution is sprayed on the plants at the time the snails are on their rounds; the snails which are attacked die

immediately and those which pass on to a branch covered with blue vitriol are likewise poisoned.

Use against Mammals.—According to Taschenberg, plants are preserved from rabbits, hares, deer, by coating with lime. It is preferable to add strong smelling substances, such as petroleum, aloes, lard (rubbing a skin of lard against the trunks of 100 trees suffices). To impart more adherence and thickness to this paste, it is well to add cow dung and thin it down with purin. Seed can be protected against mice by coating them with a thick milk of lime and spreading petroleum thereon. They are then sown immediately after this treatment. Such seed are not attacked by rodents.

Late Frosts.—Lime is successfully used against late frosts. When frost is to be feared, slaked lime in powder is spread on the buds of vines and fruit trees from a bellows so as to cover all their surface. These buds well covered with lime will not be attacked by the frost nor burnt by the sun striking them afterwards. With fruit trees it is necessary to operate before the blossoming of the flowers, or after fructification has taken place.

44. Calcium Monosulphide.—Preparation. — (1) By heating lime in a current of sulphuretted hydrogen; (2) by heating a mixture of sulphate of lime and charcoal; (3) by boiling milk of lime with sulphur; the polysulphides are so prepared, but by using larger proportions of sulphur. The product obtained by boiling milk of lime with excess of sulphur is called *calcareous liver of sulphur*. The paste bouillies employed to combat plant diseases are of very diverse compositions, and contain either a basic monosulphide or a monosulphide or polysulphides of calcium. They are generally prepared by boiling a milk of lime with flowers of sulphur, until the latter is completely dissolved. After cooling there are incorporated as occasion requires very diverse substances, such as glycerine, soft soap, copper salts, naphthalene, etc. To prepare and preserve these pastes, enamelled vessels are used. The bouillie recommended by Mohr is the one most in use. It is made thus: 22 lb. of quicklime are slaked, then made into a milk of lime and run through a sieve; on the other hand, 11 lb. of flowers of sulphur are stirred into 2·2 gallons of crude glycerine; the two liquors are mixed and the bulk made up to 22 gallons of liquid which is boiled for one hour over a small fire. A concentrated solution is thus obtained marking 18°-20° B., which is appropriately diluted when required for use, to suit it for particular purposes, with 10-12 parts of water. It is best to dilute it with a milk of lime of 0·5 per cent strength. Crouzel's anticryptogamic is prepared thus: 14 oz. of lime are slaked and the milk of lime therefrom run through a sieve, 35 oz. of sulphur added and the whole completed with water so as to produce 150 oz. of bouillie. When a homogeneous mixture is obtained, it is brought to the boil for an hour, care being taken to replace the water evaporated. The solution is filtered or decanted; it marks 20° B., 0·1 oz. of naphthalene is added and 2 oz. of hyposulphite of soda, and the whole completed with water to 100 gallons. This preparation is used as it is against the cryptogamic diseases of the vine.

Properties.—Calcium sulphides are soluble in water, and in all

proportions. Moistened with water and in contact with air they are rapidly converted into carbonate of lime and sulphuretted hydrogen.

$$CaS_2 + CO_2 + H_2O = CaCO_3 + H_2S + S.$$

But simultaneously with this decomposition they undergo partial oxidation into hyposulphite of lime. Calcium sulphides are neutral. They act by the amount of sulphur which they contain. To prevent their too rapid decomposition in moist air, various substances have been incorporated, such as glycerine and milk of lime, in the proportions given by Mohr (p. 148), molasses, soft soap, in the proportion of 1-2 per cent. These substances also cause the bouillies to adhere better to plants.

Action on Plants.—Calcium sulphides are less injurious to the green parts of plants than potassium sulphides, because their solutions are not caustic. Solutions of glycerinated monosulphide may dry on the leaves without injuring them. But in spite of that it is necessary to avoid the too rapid decomposition of these sulphides for the sulphuretted hydrogen produced is very injurious to the plant; 0·75 per cent of this gas diffused through the air may poison certain plants. The use of glycerine to form bouillies, and of water and lime to dilute them prior to use, helps greatly to attenuate the effect of this gas; by delaying the decomposition of the sulphides, too large an amount of sulphuretted hydrogen is prevented from being formed at one time. The damage caused by different plants, as well as on the roots treated, are likewise caused by hyposulphite of lime often present in impure calcium sulphides; hyposulphites scorch the leaves especially during strong summer heat. Owing to their reducing action sulphides, and particularly calcium sulphides, are injurious to the roots which come in direct contact with it. The experiments of Fithbogen, Schiller, and Förster have proved this effect.

Action on Fungi.—The action of calcium sulphide on the mycelium of fungi is in principle the same as that of sulphur, but polysulphides, which are in a way solutions of sulphur, may be looked upon as more active than sulphur, even used in its most impalpable form. Whilst sulphur has no radical action on the *Erysipheæ*, the mycelium of which is exposed without any protection on the surface of plants, calcium sulphides act on fungi which live in the plant itself.

Action on Insects.—Generally insects are not disturbed by solutions of calcium sulphide. It is otherwise with acari, plant lice, which are easily destroyed by this preparation. Sulphides are, so to speak, specifics against the *Phytoptides* which produce the different *erinoses* of plants and the most diverse galls. Used against these lice their action, otherwise very imperfect, is solely due to the sulphuretted hydrogen given off, which is exceedingly poisonous to these insects.

Use against Fungi.—Calcium sulphides form an efficacious and economic means for the destruction of the most various parasites. They are practical substitutes for sulphur. They have in themselves a remarkable action; but it is well to incorporate in their solutions substances capable of protecting them against moist air which renders them inactive too soon and causes them to poison plants. Mohr advises their use against cryptogamic diseases.

Cuscuta (dodder).—Carrigon employs calcium sulphide with success to destroy dodder in forty-eight hours. To obtain this effect calcium sulphide is spread on the ravaged parts of the field, and these spots sprayed slightly with water. The result is especially favourable in wet weather. If this treatment is applied before the maturity of the grain the dodder may be considered as eliminated from the fields.

Peronospora viticolá, De By. (mildew of the vine).—Vesque recommends polysulphides against this parasite of the vine. A bouillie is prepared for the purpose with 1 lb. of quicklime to 3 lb. of sulphur in 10 gallons of water. The leaves and the grapes are sprayed at the time the vine is usually sulphured.

Erysipheæ (mildews).—All these fungi can be destroyed by calcium sulphides; they act on their mycelium disorganizing them rapidly like sulphur. Their use is, however, more simple, their action more regular, because it does not depend on the temperature which, as regards sulphur, is one of the conditions of success. Besides, solutions being spread more uniformly on the organs of the plant attacked the action is more thorough.

Uncinula Americana, How. (oidium of the vine).—Crouzel recommends his "anticryptogamic" against the oidium, the composition of which has already been given. Spraying ought to alternate at five or six days' interval with cupric preparations. Polysulphides employed without naphthalene or hyposulphite produce the same effect, and Mohr's preparation arrests the oidium in full evolution. In the spring 4 per cent solutions of polysulphides are used, 5 per cent solutions after flowering, and 6 per cent solutions at the end of summer. The latter do not injure the leaves. In the same way as for the oidium, mildew of the vine, the polysulphides of calcium have been used to destroy the following *Erysipheæ* (mildews): *Sphærotheca pannosa* (mildew of the rose and the peach); *Microsphæra Grossulariæ*, Wall. (mildew of the gooseberry); *Erysiphe communis*, Wall. (mildew of hay and clover). Nijpels recommends to use against mildew of the rose a sulphide prepared thus: boil 100 gallons milk of lime made with 20 lb. of quicklime and 40 lb. of sulphur; after twenty minutes' boiling the sulphur is dissolved and the whole cooled. A teaspoonful of this solution per litre of water for spraying suffices, which should be done two or three times during summer.

Capnodium (fumagine).—The fumagine (fruit tree smut) is destroyed by 5 per cent sulphide solutions, but according to Franck and Kruger this product cannot destroy the cochineals which produce it.

Amongst the black-blights there are also some which may be combated with polysulphides: *Gloeosporium ampelophagum*, Sacc. (anthracnose of the vine). Against this disease it is necessary to apply a spraying of sulphide before the flowering of the vine.

Cladosporium fulvum, Cooke (tomato disease).—Mohr particularly advises the use of polysulphides against this disease which act in a more efficient manner than copper salts.

Actinonema Roseæ, Fr. syn. (Asteroma radiosium, Fr.).—Mohr recommends two or three sprayings during summer.

Hypomyces perniciosus, Magnus (mole disease).—Constantin and Dufour found that this disease can be combated by calcium sulphides.

Nectria ditissime, Tul. (canker of the pear-tree, canker of the apple-tree, canker of the beech-tree) ; *Nectria cinnibarina*, Rode. (necrosis of wood).—Mohr advises to combat these two parasites with glycerinated sulphides. The wound is deeply incised, cleaned, and then coated several times with a solution of glycerinated sulphide of calcium, titrating 15°-25° B. When the wound is dried up it is covered with a linseed oil varnish (? boiled oil). To obtain a cure it is sometimes well to repeat this treatment several times a year. It is also recommended to use a concentrated solution of sulphide mixed with a thick milk of lime and to coat the wound after drying with a mastic of some sort.

Fusicladium Pirinum, Fuckel (pear scab); *Fusicladium dentriticum* (apple scab).—Mohr advises the use of glycerinated sulphide of lime, of the usual strength, as soon as the fruits have formed and are the size of a pea, two or three additional sprayings being given during the summer.

Hydnes and *Polypores* are combated with calcium sulphides: *Hydnum Schiedermayri*, Heufl.; *Polyporus sulphureus*, Fries; *Polyporus igniarius*, Fries (false tinder fungus).—Mohr advises to combat this disease by excising all the diseased wood and to plaster the wounds several times with glycerinated sulphide of lime of 20° B., then to coat with mastic. Mohr also advises to combat certain rusts with calcium sulphide thus: *Phragmidium subcorticum*, Schrank (rose rust), and also the rust of the pines and spruces, such as *Chrysomyxa abietis*, Unger (rust of needles of Epicea), and others. The treatment should be carried out in May so as to avoid fresh infection of the plant. *Peridermium pini*, Walr. (vesicular rust of the bark of the pine)[1]; *Peridermium oblongisporium*, Fuckel (vesicular rust of pine needles).—Mohr advises to combat these diseases with his bouillie diluted with 10-12 parts of water. The result it appears is as good as with bouillie bordelaise.

Exoascus deformans, Fuckel (Cloque du Pecher), (blistering, wrinkling, or curling up of the leaves of the peach).—Pierce and Mohr advise spraying with calcium sulphide to prevent this disease; according to these authorities complete success is obtained if, as soon as it makes its appearance on the first leaves, they are sprayed with a 4 per cent solution.

Use against Insects.—*Carpocapsa pomonella*, L. (codlin moth, apple worm, pyralis of the apple).—Mohr advises calcium sulphide glycerinated to $\frac{1}{10}$ to prevent apples becoming wormy. To prevent the hatching of the eggs laid by the female on the young fruit a first spraying should be made as soon as the fruit is formed or soon after flowering; the fruit should be inspected from time to time and sprayed afresh where required.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—Mouillefert tried to determine the action of calcium pentasulphide on this louse, by

[1] Pine "cluster cups".—Tr.

making injections round an infested stock, amounting in all to 350 cubic centimetres, of a solution of 23° B. diluted with 7 litres of water [twenty times its volume]. The result was perfect on the upper roots but not complete on the deep roots.

Aphides (naked plant lice).—Many observers have recommended 2-4 per cent solutions of calcium monosulphide and even the same product in the form of powder as a specific against green lice.

Aphis Persicæ, Sulz, which is destroyed at the same time as the leaf curl (*Exoascus deformans*) by a 4 per cent solution; likewise the *Aphis Oxyacantha*, Koch, which causes the cloque of the hawthorn; *Aspidiotus perniciosus*, Comstock (San José louse); *Aspidiotus Aurantii*, Maskell (cochineal of the orange). The Canadian Government advises for the destruction of these dangerous cochineals a bouillie consisting of 18 lb. of slaked lime, 18 lb. of sulphur, and $5\frac{1}{4}$ oz. of blue vitriol in 10 gallons of water. For the same purpose there is used in California a bouillie composed of 6 lb. of slaked lime, 3 lb. of sulphur, and 2 lb. of common salt (the latter added at the moment it is to be used) in 10 gallons of water. This bouillie, it appears also, kills the woolly aphis. According to the researches of Coquillet these two bouillies even used of double strength are not capable of entirely freeing the trees from their parasites. They only destroy 50 per cent. Mohr likewise found these bouillies incapable of replacing more active ones, and Franck and Kruger regard this means as insufficient to combat the different species of cochineal. Garrigou found that calcium sulphide spread in fine powder on the young moving lice followed by spraying with water very effectual. Calcium sulphide in powder is a specific for the destruction of acari against which it yields perfect results.

Tetranchus telarius (red spider, saw-fly).—Calcium sulphide may prevent the premature fall of the leaves produced by the saw-fly; it also prevents the *erinoses* produced by the *Taphrina*, Fr., *Erineum*, Pers., and *Phyllerium*, Fr.; it also destroys the *Phytoptides* which produce galls. As a preventive against these diseases spraying round the plant and on the branches must be advised in winter after the fall of the leaf and in spring before the opening of the buds. Coating the tree with a strong bouillie so as to cover all the buds occupied by these parasites is still more efficacious. The U.S.A. Minister of Agriculture advises to destroy *Eriophyes Ribis*, Nal., syn. *Phytoptus Ribis*, Wester (currant gall mite), and *Eriophyes Vitis*, Land., syn. *Phytoptus Vitis*, Land. (erinosis of the vine), to use a bouillie consisting of 6 lb. of lime and 6 lb. of sulphur in 100 gallons of water. To increase the effect of the calcium sulphide $12\frac{1}{2}$-25 lb. of soft soap may be added. The milk of lime is boiled with the sulphur and the soft soap dissolved in water added. Miss Ormerod (the late) and also Debray greatly recommend calcium bisulphite and found it superior to sulphur. Taschenberg finds that a little alum renders its solutions more active.

45. Calcium Chloride, $CaCl_2$.—**Preparation.**—By treating marble with hydrochloric acid. The crystals of $CaCl_2 6H_2O$ thus obtained are heated to igneous fusion; the mass is then cooled on a smooth surface on which the chloride solidifies in white flakes with a crystalline fracture.

Properties.—Fused calcium chloride has great affinity for water (i.e. is highly deliquescent); in contact therewith it dissolves with evolution of heat.

Use.—Comstock and Slingerland tried this product, comparatively against other substances, to fight the larvæ of *Agriotes lineatus* (wire-worm), but did not obtain good results. Neither was Waite able to destroy lichens by the use of a 1 per cent solution, whilst Jack recommends it in strong doses to kill *Equisetum palustre*, or poisonous horse-tail, in meadows.

46. Chloride of Lime (Bleaching Powder), $CaCl_2O$.—**Preparation.**—Commercial bleaching powder is a mixture of hypochlorite of lime, calcium chloride, and lime. It is prepared by spreading slaked lime in thin layers on trays laid in a masonry chamber, and passing a current of chlorine over this moist lime, so that a certain amount of unchanged lime remains at the end of the operation, which enables the chloride of lime to keep longer, by protecting it against the carbonic acid in the air.

Properties.—Chloride of lime is a white powder with an acrid taste, exhaling an odour of hypochlorous acid, $HClO$; it dissolves freely in water, leaving a white residue of hydrate of lime. The weakest acids, such as carbonic acid, decompose chloride of lime with disengagement of hypochlorous acid; chloride of lime must therefore be preserved out of contact with air. The hypochlorous acid which is given off has a very energetic action on organic matter, towards which it acts as an oxidizing agent. This action is more rapid in presence of a mineral acid.

Use.—Kolbe recommends chloride of lime to destroy poisonous horse-tail (*Equisetum palustre*). In doses of 352 lb. per acre its destruction is complete. Chloride of lime has been used to destroy insects. It has been tried against—

Phylloxera vastatrix, Planch. (phylloxera of the vine).—The Departmental Commission of Herault which examined the processes recommended to combat the phylloxera declared the two following processes quite inefficient: Timbal's, which consisted in burying round about the stocks 20 grammes (306 grains) of chloride of lime, and Dupuis', which consisted in watering each stock with the *eau de Javel* obtained by mixing 50 grammes of chloride of lime with 12·5 grammes of carbonate of soda in 1 litre of water [in ratio of 5 lb. and $1\frac{1}{4}$ lb. in 10 gallons of water].

Spilographa Cerasi, F., syn. *Trypeta Cerasi* (cherry fly).—Taschenberg recommends to prevent cherries from becoming wormy to spread, after the fall of the cherries, around the tree a hot 1 per cent solution of chloride of lime, which destroys the larvæ buried in the ground.

Formica (ants).—Taschenberg proposes for the destruction of ants to spread on their nests a mixture of chloride of lime and of purin, or to mix the earth of the nest with chloride of lime and to water immediately afterwards with dilute hydrochloric acid. Cuboni believes that in spraying fields with a milk of chloride of lime they are freed from almost all parasites, and mice and moles are driven away. The

odour of this product would appear to be unpleasant to insects, and the presence of chloride of lime suffices to prevent them from laying their eggs. This property has been utilized in arboriculture. For this purpose a mastic is prepared, with 1 part of fat and 2 parts of chloride of lime in powder, and a ring of this preparation applied round the trunk. According to Muhlberg, it suffices to suspend on the tree a small basket filled with chloride of lime. Needless to say the chloride of lime must be renewed as soon as it ceases to emit any more hypochlorous acid.

47. **Sulphate of Lime,** $CaSO_4$. — **Preparation.**—Gypsum, or plaster stone, is a natural, crystallized sulphate of lime, $CaSO_4 2H_2O$. It is found in large quantities in the Trias and Permian. These deposits are the result of the evaporation of ancient selenitic waters and are met with in Morvan, Jura, Saone, Loire, Aveyron, Nièvre, Gard, and also in the environs of Paris, around Enghien. Crystallized sulphate of lime is rapidly and almost completely dehydrated at about 120° C., being converted into plaster of Paris, which contains no water but which retains the property of easily taking up its water of crystallization once more when again moistened. This precious property is lost if the gypsum is heated to 160° C. To obtain sulphate of lime commercially the plaster stone is piled up at the quarry mouth in rude arches under a shell made from combustible material, or in special furnaces. The blocks must leave between each other interstices of sufficient size to allow the flame of wooden faggots lit in the lower part to pass. A very moderate fire is kept up, which penetrates the mass slowly and dehydrates it. The plaster so obtained is pulverized in mills and preserved out of contact with moisture.

Properties.—Sulphate of lime is slightly soluble in water; 1 litre of water at 0° C. dissolves 1·9 grammes; at 38° C. 2·14 grammes; at 99° C. 1·75 grammes; it is much more soluble in hydrochloric acid.

Action of Sulphate of Lime.—Its action is due to its hygroscopic power and its fine division, which asphyxiates the insects by penetrating into the respiratory passages.

Use of Plaster[1] **as a Manure.**—Known to the Greeks and the Romans. Manuring with plaster has been in current use, especially since the eighteenth century. Franklin was one of its most zealous advocates. The effect produced on certain plants by sulphate of lime is so violent that scientists are not yet quite agreed as to the explanation. Plaster contains two elements necessary to plants, sulphuric acid and lime; by supplying these two substances to the soil plants necessarily thrive better than if deprived of these two elements. Although plaster cannot be regarded like lime as capable of changing the physical and chemical composition of the soil, it, however, restores to the soil in a soluble form the sulphuric acid and lime removed by crops. The effects of plaster may thus make themselves felt

[1] The author does not differentiate between gypsum and plaster but uses the term *plâtre* throughout. To follow him it will be well to bear in mind that in all probability when he refers to plaster as a manure he means gypsum, and when he refers to plaster as an insecticide he means plaster of Paris. It is a pity that writers on agricultural chemistry too often lose sight of the fact that superphosphate contains naturally about 50 per cent of sulphate of lime in addition to what is added as a "reducer".—Tr.

even on calcareous soils when the latter is deficient in sulphuric acid. If we calculate the amount of sulphuric acid removed from the soil by crops we get the following figures per hectare: 5·8 kilogrammes for grain crops, 6·1 kilogrammes for leguminous seed crops, 14·1 kilogrammes for leguminous fodder crops, 7 kilogrammes for industrial plants, 43·4 kilogrammes for root plants, 12 kilogrammes for tubers. These amounts of sulphuric acid must therefore be returned to the soil, as well as the other elements recognized as indispensable to vegetable life. The analyses of the ash show that all plants have not such an affinity for salts containing sulphuric acid; thus plaster does not produce the same effect on different crops. Plastering, which is excellent for leguminosæ, is of less value to cruciferæ, tobacco, flax, hemp, millet, and only slightly improves cereal crops. On the other hand, plastering is capable of quintupling the crops of leguminous fodder plants, such as lucerne, sainfoin, trefoil, and tares. Plaster has thus an indirect action on the composition of the soil in rendering soluble and assimilable for plants the compounds in the soil which contain potash. The property which sulphate of lime possesses of rendering the potassic compounds diffused through certain soils soluble has been recognized by Peters. Déherain has shown that when plaster is added to the soil the formation of sulphate of potash is induced, and it is found that trefoils manured with plaster contained more potash in their ashes than the check samples. The sulphate of potash forms in contact with the carbonate of lime which encloses and renders the humic matter insoluble, carbonate of potash, which dissolves the humus. Owing to this action plaster is especially favourable on soils rich in humus. But argilo-calcareous and silico-argillaceous soils, impermeable, humid, and cold vitiate this action. Plaster can thus not only improve the crops which require its constituent elements, lime and sulphuric acid, but likewise those which require potash or humus. It acts, therefore, with advantage on soils rich in humus or well-manured ground. Applied in large doses along with good manuring plaster gives excellent effects in vine-growing. It is the chemical analysis of the soil and that of the ash of plants which can alone furnish information as to the necessity for plastering and on the quantity to spread on the fields, for the proportions of plaster to use in all soils cannot be given exactly. Muntz and Girard advise massive doses at distant intervals owing to the comparative solubility of sulphate of lime. On the other hand, they recommend only to make plastering really useful to the growing plant at the moment of spreading. This treatment will, therefore, be every two years for hardy leguminous plants, such as lucerne; for meadows, which form part of a rotation, plastering is only done when their turn comes round. When clover is grown with a grain crop it is better not to plaster the ground until after the grain crop has been harvested, and not at the time of sowing the seed so that the treatment may only benefit the leguminous crop. As already said, it would likewise be well for the vine-grower to use plaster along with abundance of manure. The average dose per hectare is 400 kilogrammes the first year and 200-300 kilogrammes the following year. The most favourable time for plastering

is in the spring, preferably at the time the young buds begin to grow; it is done under cover by dusting the fields as regularly as possible. Working thus the plaster has the further advantage of guaranteeing the young plants so covered against the rigours of late frost. Plaster used in arboriculture is regarded as an injurious manure causing the fruit to rot.

Use against Late Frosts.—The adhesion of plaster and its siccative power permit its use against the late frosts of spring. The "powdering" used for some years in France and very much in vogue in Italy may entirely preserve the vine against late frosts so dreaded in viticulture. By means of a sulphurator the plaster is spread as an impalpable powder on the vines at the time frosts are feared. In Italy plastering is associated with the treatment for the mildew of the vine oidium, using a mixture containing $\frac{1}{3}$ of sulphide and $\frac{2}{3}$ of plaster (wood ashes and lime are also used for the same purpose in Italy). Ouvray advises to utilize this same process against frost to preserve flowers, or the very delicate young fruit of fruit trees; powdering is, therefore, done say a little before flowering or immediately afterwards. Powdering forms an economic and efficient protection against frost and may find numerous applications in the culture of marshy land.

Use against Fungi.—Sorauer advises abundant manuring with plaster to prevent the rotting of roots due to the development of the most diverse fungi, such as *Armillaria mellea*, Quellet, *Fibrillaria xylothrica*, Linh., *Rhizoctinia violacea*, Tul.; this manuring has sometimes given good results.

Botrytis cinerea,[1] Pers. (grey rot of the vine).—Sorauer advises the use of plaster in the same condition as slaked lime in fine powder. As soon as this dreaded disease appears, plaster is sprayed on the fruits; the fruits are thus protected, for the fine layer of plaster which covers them prevents the fungi from finding on the surface of the grape a propitious soil for their development. Recommended for the first time by De la Bathie, experiments made in the South of France have not given the good results described.

Use against Insects.—Plaster having no caustic action can only act as an asphyxiant. Owing to its extreme fineness, it is introduced through the stagmata into the respiratory organs of insects, where under the influence of moisture it hydrates, swells, and causes death. Without being mortal to certain larvæ, it annoys them very much and keeps them away from plants. Plaster is used with much greater success against *altises*. *Haltica ampelophagus*, Guer. (altise of the vine). —So that the effect may be perfect, it is necessary to powder the vine so that the plaster is projected on to the lower part of the leaves, for it is there that the larvæ and insects are. Brocchi greatly advises its use. But it is not the altise of the vine alone which may be combated in this way, the most diverse altises succumb or are driven away owing to its use.

Haltica nebulosa, L. (Cassida nebulosa).—Dœring advises the use of plaster against this larvæ as well as for the caterpillar of *Noctua gamma*.

[1] The conidia of *Sclerotina Fuckeliana*, De Bary.—Tr.

Plusia gamma, L. (silver Y moth).—The caterpillars of this *Noctua* abandon plants treated by plaster.

Melolontha vulgaris (cockchafer).—Poli recommends to kill this larva to plough in 8 cwt. of plaster per acre along with the cruciferous plants grown for this purpose as intercalated crops. Plaster does not, however, act as such, but owing to the sulphuretted hydrogen evolved by the fermentation in presence of organic matter.

Hypera variabilis (beet weevil).—Plaster renders the same service as lime in destroying the larvæ of this insect in lucerne fields. It suffices to throw a certain amount with the shovel on the infested plants. The larvæ of the saw-fly succumb by powdering them with plaster as well as with lime (Taschenberg).

Snails and Slugs.—Plaster used like lime destroys these mollusca.

Rodents.—Rodents are often destroyed by plaster. It is spread on a saucer and covered with a layer of flour, a second saucer is filled with water. The rodents begin to eat the flour, of which they are very fond, then the plaster. When they go to slake their thirst the plaster swells and agglomerates in their stomachs, causing death.

Sulphite of Lime, $CaSO_3 2H_2O$.—**Preparation.**—By treating milk of lime or chalk beaten up with water by sulphurous acid.

Properties.—Sulphite of lime only dissolves in 800 times its weight of water, but it is very soluble in sulphurous acid with which it forms calcium bisulphite.

Use.—Dufour tried sulphite of lime against the *Dematophora necatrix*, Hartig. (white root rot), but he did not find it effectual J. de Sokolnicki used with success against the *Botrytis cinerea*, Pers. (grey rot of the vine) a powder of the following composition : alumed plaster 20 lb., bisulphite of lime 10 lb., Portland cement 15 lb., hydraulic lime 20 lb., green vitriol 35 lb. This powder used on vines from 8 May and during flowering kept the grapes free from rot. It is, moreover, known that bisulphite of lime destroys moulds because it is regarded as the best disinfectant for cellars infested with mould. It is also used to destroy the cryptogams which infest dairies, and for the preservation of beer. It is to be remarked that the mixture used against the black rot does not act solely through the bisulphite of lime, but rather by the alum.

48. **Calcium Carbide,** CaC_2.—**Preparation.**—By acting on an intimate mixture of quicklime and powder, with the high temperature of the electric furnace.

Properties.—It forms hard, compact scoriaceous masses without smell in dry air. In moist air it gives off an alliaceous odour. In contact with water it disintegrates and decomposes into hydrate of lime and acetylene.

Use.—See acetylene.

49. **Calcium Phosphide,** Ca_3P_2.—**Preparation.**—By passing the vapours of phosphorus over sticks of chalk heated to redness.

Properties.—Calcium phosphide decomposes into water and lime, and into phosphuretted hydrogen, a poisonous gas.

Use.—Mouillefert used this substance with the object of destroying the phylloxera. For this purpose he exposed some roots infested

by this insect in a 2-litre flask. Then he introduced 0·2 grammes of calcium phosphide which slightly moistened gave 20 cubic centimetres of phosphuretted hydrogen. This atmosphere contained 1 per cent of asphyxiant gas, and was capable of killing the phylloxera in fourteen hours. The numerous trials which were made on plants in pots and on the large scale led Mouillefert to the following conclusion :—

Phosphide of calcium by the phosphoretted hydrogen which it gives off in decomposing, may kill the phylloxera when the insect is exposed to its action in an open, short-necked bottle, although, however, this substance may be much less energetic than potassium cyanide and carbon disulphide. But used on phylloxera-infected vines, in pots or in vineyards, this phosphide has, so to speak, no action on insects, which is probably due to the deleterious gas being rendered harmless by the air and by the soil which burns it, and converts it into products without action on the phylloxera.

50. Arsenite of Lime, $Ca_2As_2O_5$.—**Preparation.**—The paste of arsenite of lime used to destroy injurious insects is made by dissolving 1 lb. of white arsenic in 2 gallons of water, and running into the solution a milk of lime containing 2 lb. of lime. The mixture is then heated for half an hour then thinned to make 100 gallons of bouillie. The arsenite of lime formerly used was the residue from the manufacture of magenta; it consisted largely of arsenite and arseniate of lime, and was sold under the name of London purple. As it was partially soluble in water it was necessary to add to it to render it harmless to plants an equal amount of quicklime under the form of milk of lime. In America they have even used a paste consisting of 60-120 grammes of London purple and 1·5-2·5 kilogrammes of lime in 100 litres of water.[1]

Properties.—Arsenite of lime is insoluble in water. The precipitate is light and keeps in suspension much better than the arsenite of copper. It has the advantage of being cheaper than Scheele's green and emerald green (Paris green), this is especially so as regards London purple, but the latter is variable in composition and its action on insects is comparatively weaker. Arsenite of lime owing to its insolubility in water is much more harmless to plants than arsenite of copper. Whitehead found the following doses harmless :—

45 grammes of purple in 100 litres for apple-trees.[1]			
50	,,	,,	pear and cherry-trees.[1]
60	,,	,,	the plum, hazel, and cherry-trees.[1]

The bouillie made with an excess of milk of lime is, so to speak, harmless to plants.

Use.—Arsenite of lime is used wherever arsenite of copper is capable of destroying injurious insects. Arsenite of lime has the advantage over arsenite of copper that it may be associated with *eau celeste* (p. 260 *et seq.*) without dissolving therein. The bouillie thus obtained is one of the most efficient in simultaneously combating the following injurious insects and fungi :—

[1] *Note by Translator.*—Grammes per 100 litres = parts by weight per 100,000 parts by volume or lb. per 10,000 Imperial gallons.

Fusicladium dentriticum, Fuckel (apple scab); *Carpocapsa pomonella* (pyralis of the apple, codlin moth).—The efficient bouillie contains London purple or arsenite of lime 0·050 per cent, copper carbonate 0·45 per cent, ammonia 0·5 per cent. After six sprayings made on 25 March, 1, 15, and 20 May, 26 June, and 14 July, Halstedt obtained 47·6 per cent of sound apples and 3·46 per cent of wormy apples, against 30 per cent of sound apples and 6·7 per cent of wormy apples. The same result was got by a mixture of bouillie bordelaise and London purple. Carrol by three sprayings on apple-trees, the first soon after flowering, the two others at three weeks' interval, obtained apples quite free from worms, whilst the check samples contained 60 per cent. The first spraying and the second were done with a bouillie containing 0·06 per cent of London purple and 1-2 per cent of lime, the third with a bouillie containing 0·1 per cent of purple and 2 per cent lime.

CHAPTER IX.

MAGNESIUM CHLORIDE — MAGNESIUM SULPHATE (EPSOM SALTS) — MAGNESIUM BISULPHITE — MAGNESIUM SILICATE (TALC SOAPSTONE)—ALUM—ALUMINIUM SILICATE (CHINA CLAY)—ZINC SULPHIDE—ZINC CHLORIDE — ZINC SULPHATE—ZINC BORATE—ZINC SILICATE — ZINC FERROCYANIDE — ZINC SULPHOCARBONATE — CADMIUM SULPHATE.

51. Magnesium Chloride, $MgCl_2$.—**Occurrence.**—Naturally in sea-water and as double salt in carnallite, KCl_2MgCl_2, in the Stassfurt mines.

Preparation.—By dissolving magnesia in dilute hydrochloric acid and evaporating the solution, the magnesium chloride is deposited as crystals.

Properties.—Very soluble in water, its taste is bitter. In medicine it is used as a purgative; it is more active than the sulphate of magnesia. [Absorbs moisture from the air-deliquesces.]

Action of Magnesia on Plants.—Magnesium salts are comprised amongst the alimentary substances indispensable to plants. Ch. Dassonville found that plants watered with solutions of magnesium chloride first suffered a retardation in their growth and sprung up more rapidly afterwards. Loew states that a certain amount of magnesia and lime is required in the soil to obtain a maximum crop. Goessel made artificial cultures to fix these proportions with various amounts of these two oxides, and found that growth was at a maximum when the media contained the lime and magnesia in the proportion of 0·4 to 1. Katayama is of the same opinion as Loew in regard to the presence in the soil of these two oxides; he believes the ratio CaO : MgO as 2 : 1 as the most favourable for plants. Möller found that the absence of magnesia in certain soils had a marked influence on the normal evolution of a plant. The pine, for example, suffers and its leaves turn yellow at their extremities if it grows in a soil too deficient in magnesia. It then suffices to water the tree with a solution of sulphate of magnesia, or of chloride of magnesia, to re-establish the normal green coloration of the leaves. The analysis of yellow leaves compared with those of a normal green gave in the first case 0·279 per cent, in the second case 0·607 per cent magnesia. Towards strong doses in the soil plants behave very differently. Steglich studied the action of magnesium chloride on plants by watering alternately with a solution of 30 and 15 per cent, and at the end of his investigations prepared the following table :—

TABLE XX.—*Showing the Effect of* 30 *per cent and* 15 *per cent Solutions of Magnesium Chloride on Plants* (*Steglich*).

Crop.	30 *per cent Solution.*	15 *per cent Solution.*
Grain . . .	Suffered slightly	Did not suffer at all
Beet . . .	Did not suffer	Did not suffer
Potatoes . .	Killed	Killed
Peas . . .	Killed	Unattacked
Trefoil . . .	Suffered slightly	Unaffected
Lupins . . .	Strongly attacked	Slightly attacked
Mustard . .	Killed	Destroyed
Charlock . .	Slightly damaged	Insensitive
Sorrel . . .	Unaffected	Intact
Horse-tail . .	Suffered slightly	Unaffected

Hitchcock and Carleton tried the action of magnesium chloride on rust of cereals. They found that a 1 per cent solution prevented the germination of the uredospores of *Puccinia coronata*, Corda, after steeping for twenty-seven hours.

Use.—In strong doses magnesium chloride may be used to replace green vitriol to destroy charlock in cereal crops; it may act at the same time as a manure. Trials made up to now with a 20 per cent solution, at the rate of 35 gallons per acre, have given good results. As a manure, it is recommended in pine nurseries to cure the yellow leaves of the pines which show a deficiency of magnesia in the soil.

52. Magnesium Sulphate, $MgSO_4 7H_2O$.—**Preparation.**—By evaporating the waters of certain springs such as Epsom[1] in England, and Seidlitz in Bohemia. But it is obtained more readily by attacking dolomite by hot dilute sulphuric acid; a mixture of insoluble sulphate of lime is formed and soluble sulphate of magnesia which is separated by filtration.

Properties.—Magnesium sulphate crystallizes with 7 molecules of water[2]; 100 parts of water dissolve 26 parts of calcined magnesium sulphate at a temperature of 0° C. and 72 parts at 100° C. It possesses a bitter taste and is generally used in medicine, in which it is administered as a purgative. In the vegetable economy it plays the rôle of magnesium chloride, that is to say, dissolved in small amount in distilled water it is capable of prolonging the growth of plants; when the plant is strengthened it becomes indispensable to it. In 1853 the experiments of J. Pierre in the plain of Caen showed that magnesium sulphate could render the same service as plaster in agriculture.

Use.—This product may be used to combat charlock in grain crops in the same way as magnesium chloride. Magnesium sulphate was recommended in 1852 to combat an insect injurious to beets termed—

Atomaria linearis, Steph.—Kuhn recommends to combat this insect to immerse the beet-seed before sowing for twenty minutes in a steep

[1] Hence the trade name of Epsom Salts.—Tr.

[2] It is an efflorescent salt, i.e. loses most of its water of crystallization in a dry, open atmosphere.—Tr.

of 5 per cent of sulphate of magnesia and 1 per cent carbolic acid. Although of an efficiency which is highly contested, followers of this practice include responsible experts (Marek, Pagnoul).

Peronospora viticola, De Bary (mildew of the vine).—Solutions of magnesia sulphate act on the spores of this fungus, but they are not so poisonous as the salts of copper, so the experiments of Sbrozzi on diseased vines gave only very imperfect results.

53. **Magnesium Bisulphite,** $MgH_2(SO_3)_2$.—**Preparation.**—By treating magnesia stirred up in water with sulphurous acid.

Use.—*Botrytis cinerea, Monilia frutigena, Coniothyrium diplodiella.*—Istvanffi found that bisulphite of magnesia had the same action on spores of these fungi as calcium bisulphite, of which an 0·5 per cent solution acted in the same conditions eighteen times more energetically than a 10 per cent solution of bouillie bordelaise. He advises the use of a 0·4-0·5 per cent solution of bisulphite of lime or magnesium to combat these fungi, a dose which can be increased to 1 per cent without drawback.

54. **Silicates of Magnesia.—Occurrence.**—Two natural silicates may be used against plant diseases; they are steatite, $3SiO_2 2MgO_2$, talc, $5SiO_2 4MgO$. These two compounds are widely distributed in nature.

Properties.—The silicates of magnesia are neutral, inactive bodies insoluble in water. Owing to their fine division [and unctuosity] steatite and talc show a very great adherence to plants.

Use.—Their extreme fineness and lightness render steatite and talc highly appreciated for assuring to anticryptogamic substances a perfect distribution on diseased plants. These two silicates, therefore, enter into the composition of a large number of powders. Their rôle is to dilute the active principle.

Uncinula Americana, How.—One of the chief uses of talc is in the *Poudre fonta* used against oidium and consisting of talc 90 per cent, sulphur 10 per cent.

Peronospora viticola, De By.—Steatite and talc are the most appropriate substances for the preparation of copper powders used to combat mildew. Sulpho-steatite consists of talc and blue vitriol. The powder Fostit made at Antwerp contains 90 per cent of talc and 10 per cent of blue vitriol. These two preparations are those most used, as owing to their lightness they penetrate vines better than any other preparation.

Botrytis cinerea, Pers. (grey rot of the vine).—The powder which has been most successful against this disease is that used by Dr. Baretto, on the advice of the Baron de Chefdebien. It consists of talc 92 per cent, sulphate of alumina 3 per cent, sulphate of lime 4 per cent, green vitriol 1 per cent. This mixture should be applied by copious dusting before and after flowering if it be desired to remove mould; if it be desired to arrest the grey rot it is necessary to apply this treatment every ten to twelve days after the disease appears.

According to recent trials talc does not play any active rôle in this preparation; the active agent is the sulphate of alumina; the sporicidic property in this special case is superior to that of blue vitriol. But

the mechanical action of the talc must play an important part in this preparation, as Jean Burnat has obtained as excellent results as Baretto with the following preparation which did not contain sulphate of alumina: cement 20 per cent, soapstone 30 per cent, hydraulic lime 50 per cent. Burnat uses this mixture in copious powderings after previously moistening the diseased vines with a solution of soft soap. These two preparations are the only ones which, with that of Sokolnicki, have given satisfactory results in the treatment of grey rot of the vine.

55. **Alum,** $Al_2 3(SO_4)K_2SO_4 24H_2O$. — **Preparation.** — Ordinary alum is a double sulphate of alumina and potash. To prepare alum pure clays are calcined in a reverberatory furnace and then pulverized and mixed with 40 per cent of sulphuric acid, 52° B. The mixture is kept for several days at a temperature between 60° and 80° C., at the end of which time the silica is deposited; the alumina is dissolved as sulphate of alumina, which, decanted and mixed with sulphate of potash, produces crystals of alum in the form of regular octahedra.

Properties.—Alum is a colourless salt of a sweet and astringent taste, much more soluble in hot water than in cold. Alum solutions have a slight acid reaction.

Action of Alum on Plants.—The vine does not stand this product and dies if it be watered with a 5 per cent solution of alum (Mouillefert).

Action of Alum on Fungi.—Kuhn examined in 1872 the action of an alum solution on the diseases of cereals produced by the fungi *Ustilago* and *Tilletia.* After fifteen hours' action on the spores some were still capable of germinating. According to the laboratory tests of Ravaz and Guirand aluminium sulphate has a decided action on *Botrytis cinerea.* This action is more evident than that of blue vitriol, which is almost nil; whilst, according to Millardet, the spores of *Peronospora viticola* are killed by a solution of 3 in 10,000,000, those of *Botrytis cinerea* still develop in a solution of 3 in 1000 of blue vitriol.

Action on Insects.—Alvood found that a 3 per cent solution and even a 9 per cent solution does not kill cabbage grubs and lice. Neither does it kill the larvæ of the gooseberry saw-fly, *Nematus ventriculosus,* Kl.

Use.—*Botrytis cinerea* (grey rot of the vine).—Amongst the substances recommended to combat this fungus two preparations have been recommended and given good results; they both contain alum or sulphate of alumina. Sokolnicki's contains 20 per cent alumed plaster [alumed plaster is obtained by adding 10 per cent of alum to plaster beaten up with water and reheating it], that of Baron de Chefdebien 3 per cent of aluminium sulphate. [The composition of both these mixtures has been given under calcium bisulphite and talc.] The two compositions were successfully used in Brazil and in the department of the Gironde, and their efficacy is undoubted, yet De la Bathie got no result by using a bouillie containing 0·5 of alum or sulphate of alumina and a little lime.

Schizoneura lanigera, Hausm. (woolly aphis).—Alum has been advised and frequently used for a very long time to combat this louse. Some results were got by a solution of 2 per cent alum and 4 per cent

soda. Mohr advises a mixture containing 4 per cent alum and 5 per cent amylic alcohol (fusel oil) to destroy larvæ without down at the moment they are hatched from the winter egg [Nov.-Dec.]. But this mixture does not seem to kill eggs and adults. The rôle of amylic alcohol in the destruction of these larvæ is not unimportant, for no appreciable result was got in recent trials made with concentrated solutions of alum alone. This method is, moreover, contested by Muhlberg. Advised by Radan in 1872 to combat the phylloxera Mouillefert found the dose of 100 grammes of alum (say $3\frac{1}{2}$ oz.) per stock without action on the insect but apt to kill the vine.

56. Silicate of Alumina (clay).—**Occurrence.**—Pure silicate of alumina is known as kaolin ("china clay") and "plastic clay"; mixed with carbonate of lime it forms potters' clay.

Properties.—Mixed with water, clay forms a supple, plastic, and unctuous paste.

Use.—In virtue of its special properties clay is used to guarantee the bark of trees against the bites of leporides or to asphyxiate xylophagous insects. For this purpose it is mixed with cow-dung and often with ox-blood or curdled milk The following insects *inter alia* may be got rid of in this way:—

Agrilus sinuatus, Ol. (burn-cow of the pear-tree).—To prevent the burn-cow from laying its eggs the trunks and branches of the tree are coated with potters' clay; to fight the larvæ and asphyxiate them in their burrows the whole of the bark must be coated with a mixture of potters' clay and cow-dung, and a band of cloth applied on this coat. Goethe found this treatment good. It can also be used against scolytes and bostriches such as *Scolytus Pruni*, Ratzeb. (scolytus of the plum), *Scolytus rugulosus*, Koch (rugose scolytus), *Tomicus dispar*, Fbr. (bostriche different). To protect fruit trees against these three insects the trunk and branches are coated with a mixture of lime and clay.

Cochineals.—To kill cochineals a very old method consists in coating the trees invaded with the following composition: Clay, soot, cow-dung, sulphur beaten up with water to a pasty consistency.

Rabbits.—To prevent rabbits from nibbling the bark of fruit trees these are coated at their base with one of the following preparations: (1) Potters' clay 2 lb., cow-dung 2 lb., ox-gall 1 lb., bullock's blood 1 lb. This mixture is stirred up with purin to a pasty consistency. (2) Potters' clay 2 lb., curdled milk 2 gallons, blood 2 gallons, purin 6 gallons. (3) Asafetida $1\frac{1}{4}$ lb., blood 8 gallons, with sufficient cow-dung and clay to give a smooth paste. The odour of these coatings being very repugnant to rabbits keeps them at a distance.

57. Zinc Sulphide, ZnS.—**Preparation.**—By adding sodium sulphide to a solution of zinc sulphate. The white precipitate is filtered and washed.

Properties.—Zinc sulphide is insoluble in water.

Use.—Fairchild used a zinc sulphide bouillie, made by precipitating sulphide of zinc by a solution of liver of sulphur against (1) *Phyllosticta sphæropsidea*, E. and E. (spots of the leaves of the chestnut) and against (2) *Entomsoporium maculatum* (spots of the leaves of the pear-tree). Result in (1) appreciable, in (2) nil.

58. Zinc Chloride, $ZnCl_2$.—**Preparations.**—By dissolving zinc clippings [or zinc scrap] in dilute hydrochloric acid. By evaporating the solution the anhydrous salt, butter of zinc, is obtained.

Properties.—Zinc chloride is a white deliquescent solid soluble in water in all proportions; exposed to air it liquefies rapidly.

Action on Fungi.—Zinc chloride behaves like zinc sulphate (Wuthrich). All remarks made on zinc sulphate (farther on) apply to zinc chloride. Tried comparatively against copper compounds on the *Peronospora viticola*, De By., by Sbrozzi, its effect was inferior to blue vitriol. By the use of a 1 per cent solution the uredospores of *Puccinia coronata*, Corda, are checked in their development [Hitchcock and Carleton].

59. Zinc Sulphate, $ZnSO_4$, $7H_2O$ (white copperas).—**Preparation.**—By roasting crude zinc sulphide at a low temperature a mixture of zinc and iron sulphates is formed which is dried and calcined to decompose the sulphate of iron. The mass is then lixiviated with hot water, filtered, and the solution of zinc sulphate evaporated to crystallization.

Properties.—Zinc sulphate forms colourless crystals with a bitter styptic taste. It dissolves in $2\frac{1}{2}$ times its weight of water at 15° C. and in its water of crystallization at 100° C. It is used in medicine as an emetic in doses of 8-15 grains, as a *collyria*, gargle, and injection. It is used as a disinfectant; it acts like sulphate of iron.

Action of Zinc Sulphate on Plants.—Sulphate of zinc shares the property that the sulphates of iron, copper, and other salts have of stimulating the growth and vitality of the plant if absorbed in small doses and of being poisonous in large doses.

In 1869 Raulin described this action on *Aspergillus niger*. Richards then Ono examined this property of zinc sulphate on *Aspergillus niger*, *Penicillium glaucum*, and the algæ *Protococcus* and *Chroococcus*, *Stigeoclonium* and *Hormidium*, and determined the stimulating action of zinc salts. As soon as the dose is higher than that required for stimulation, these salts retard or prevent the formation of spores. The dose required to stimulate algæ is much less than that required to stimulate fungi. Kanda made similar trials with Pisum and found that the stimulating action of zinc sulphate is produced when the nutritive solutions do not contain more than 0·00000015 to 0·0000030 per cent of zinc sulphate. Nobbe, Bässler, and Will found that peas and maize died in three days if the nutritive medium in which they grew contained 1 per cent of zinc as nitrate of zinc. This poisonous action is much less pronounced and sometimes does not occur in darkness (Baumann). Many plants, chiefly conifers, bear without injury 1 per cent sulphate of zinc without dying but afterwards show great defects in growth (Baumann). König found in fact 2·78 per cent of zinc in the ash of beech and maple stunted by slow poisoning by zinc. There even exist plants which seek media rich in zinc minerals for their development; these are *Viola lutea* (*forma calaminaria*) and *Thlaspi alpestre*. Zinc salts behave like blue vitriol and other poisonous salts in nutritive solutions where the roots are in direct contact with the soluble salts; these are poisonous in comparatively small doses because the plants readily absorb them in large quantities, but the same plants cultivated

in the soil bear strong doses because they are there converted into insoluble salts, the roots of which only absorb small quantities incapable of producing a poisonous effect. Haselhoff and Gössel found that the presence of 0·235 per cent of zinc oxide in a soil does not injure vegetation but that zinc sulphate in the same dose calculated as oxide was poisonous.

Action of Zinc Sulphate on Cryptogamic Parasites.—According to comparative experiments by Wuthrich zinc sulphate acts like green vitriol, and in the same doses as the latter destroys the spores of different fungi. It is thus like green vitriol 10 times less poisonous than blue vitriol and 100 times less active than mercuric chloride, the three salts being used in solutions containing their chemical equivalents.

Phytophthora infestans, De By.—The conidia treated by a 0·0143 per cent solution are weakened, and after fifteen hours in a 0·143 per cent solution destroyed. The zoospores of this fungus are stunned in a minute in a 0 143 per cent solution and killed in fifteen hours.

Peronospora viticola, De By.—The conidia are weakened by a 0·00143 per cent solution. Their growth is stopped by 0·0143 per cent solution.

Puccinia graminis.—The uredospores and the æcidospores are arrested in their growth by the action of a 0·143 per cent solution.

Ustilago Carbo (smut).—The growth of the conidia is retarded by a 0·143 per cent solution, but they are not killed by a 1·430 per cent solution. According to Madame de Ponsard, spores immersed for four hours in a 1 per cent solution partially germinated.

Claviceps purpurea, Tul. (ergot).—The conidia are not killed by a 1·43 per cent solution.

Use.—*Peronospora viticola*, De By. (mildew of the vine).—Following experiments by Wuthrich who showed that the action of zinc sulphate on the spores of this fungi is evident though comparatively weak, Guocdenovic made experiments with a 1·0-1·5 per cent zinc carbonate with a bouillie made by mixing solutions of zinc sulphate and sodium carbonate. The results were not comparable with those obtained by the Burgundy bouillie nor the bouillie bordelaise. Passerini's experiments also showed that a bouillie with a zinc sulphate basis had no curative action, like copper bouillies.

Ustilago.—Advised by Mme. de Ponsard in 1 per cent doses for disinfecting seed-corn, zinc sulphate did not give the results expected. Loverdo regards its prophylactic action as doubtful and inefficient. He regards the salt as unfit to replace copper salts.

Phylloxera vastatrix, Planch.—Mouillefert completely destroyed the phylloxeras on an infested root by steeping it in a 1 per cent solution of zinc sulphate.

60. Borate of Zinc, ZnB_4O_7.—**Preparation.**—By precipitating a solution of zinc sulphate by [a solution of] borax. On mixing the concentrated solutions a gelatinous precipitate is obtained.

Use.—Galloway examined on *rust* the effects of a bouillie made by precipitating 133 grammes of zinc sulphate by a concentrated solution of 133 grammes of borax and making the whole up to 15 litres. Oats

and summer wheat treated on 6, 16, 20 June and 5 July were free from rust and gave an excellent yield in grain, 284 grammes against 240 grammes on the check plot of the same size. He regarded this preparation as efficient against rust. Fairchild was less fortunate. The experiments undertaken by him to prevent—

Phyllosticta sphæropsidea, E. and E. (spots of the leaves of the chestnut), *Entomosporium maculatum* (spots of the leaves of the pear, leaf scald), gave a negative result.

61. **Silicate of Zinc.**—*Phyllosticta sphæropsidea* and *Entomosporium maculatum*, Lev.—Silicate of zinc bouillie produces no perceptible effect.

62. **Zinc Ferrocyanide.**—The zinc ferrocyanide bouillie examined by Fairchild although perfectly adherent had no appreciable effect against *Entomosporium maculatum*, Lev. (spots of the leaf of the pear-tree), whilst injuring the leaf.

63. **Sulphocarbolate of Zinc.**—The phenol sulphonic salt of zinc cannot prevent *Peronospora viticola* (mildew), nor replace copper preparations. All attempts to replace copper salts by zinc salts have failed, because the latter have no salutary effect except in large doses with which plants cannot be put in contact; besides as the sporicidic capacity of zinc salts is not superior to iron salts, they can in no way act similarly to copper salts, and can never replace these in their numerous prophylactic and therapeutic applications.

64. **Cadmium Sulphate,** $CdSO_4 4H_2O$. — **Preparation.** — By roasting cadmiferous blends, or by dissolving cadmium oxide or carbonate in sulphuric acid.

Properties.—Cadmium sulphate is very soluble in water; it dissolves in a little less than double its weight of water; its crystals are colourless. By dissolving sulphate of cadmium by an excess of soda or by milk of lime, a white gelatinous cadmium hydrate is obtained soluble in ammonia.

Use.—*Peronospora viticola*, De By. (mildew of the vine).—Cadmium sulphate was tried comparatively against copper sulphate, likewise a bouillie made from cadmium sulphate and milk of lime was tried against bouillie bordelaise. Ravaz and Bonnet made in 1898 five sprayings on vines, 14 and 25 May, 22 June and 3 August, and some days before the fall of the leaf, with (1) 0·5, 1·0, and 2 per cent bouillie; (2) a 0·5 and 0·25 per cent solution of sulphate of cadmium on a neighbouring plot; (3) spraying with bouillie bordelaise of 0·5, 1·0, and 2·0 per cent, and (4) a solution of copper sulphate of 0·25 and 0·5 per cent. They found that preparations with a cadmium basis of equal strength had the same anticryptogamic effect as those with a copper basis. Analogous experiments by Sbrozzi, and by Guocdenovic, did not give such favourable results; they found the action of preparations with a cadmium basis always inferior to corresponding preparations with a copper basis, and regard cadmium salts as incapable of replacing copper salts in the struggle against anticryptogamic diseases of plants. Passerini also found that cadmium salts are incapable of replacing copper salts, because their anticryptogamic action is too weak.

CHAPTER X.

IRON PEROXIDE — IRON BOUILLIES — IRON SULPHIDE — IRON CHLORIDE — GREEN VITRIOL — POTASSIUM FERROCYANIDE — PRUSSIAN BLUE.

65. Hydrate of Sesquioxide of Iron (Ferric Hydrate), $Fe_2(HO)_6$. —**Preparation.**—By precipitating a solution of sulphate of iron (green vitriol) by caustic alkali or by milk of lime.

$$FeSO_4 + 2KOH = Fe(OH)_2 + K_2SO_4.$$
$$FeSO_4 + Ca(OH)_2 = Fe(OH)_2 + CaSO_4.$$

The hydrate of the protoxide of iron, ferrous hydrate, a greenish-white precipitate which is first formed, oxidizes afterwards in contact with the air, and is converted into hydrate of sesquioxide of iron ferric hydrate, which is yellowish-brown.

$$2Fe(OH)_2 + H_2O + O = Fe_2(OH)_6.$$

The bouillies used against plant diseases were made from 1-15 lb. of green vitriol and $\frac{1}{2}$-8 lb. of quicklime per 10 gallons of water. Their preparation is similar to the bouillie bordelaise. The green vitriol is dissolved in 5 gallons of water, and the quicklime made into milk of lime is run with 5 gallons of water into the green vitriol solution with suitable stirring. The bouillie should have a slight alkaline reaction.

Properties.—The ferric bouillie has the physical properties of the bouillie bordelaise and behaves like the latter, both as to its adherence and the solubility of its precipitate by atmospheric agents.

Action of the Ferric Bouillie on Plants.—There exists between the iron bouillie and sulphate of iron (green vitriol) the same relation as between bouillie bordelaise and sulphate of copper (blue vitriol). The sulphuric acid of the sulphate of iron being neutralized is in an inert and insoluble form; the sulphate of lime does not scorch the leaves like green vitriol solutions exceeding 2 per cent. But the hydrate of sesquioxide of iron engulfed in the sulphate of lime, and in an excess of lime, has not however such a rapid action on the chlorotic condition of the plants treated as solutions of green vitriol. Dufour has shown that iron placed in contact with the plant in this slightly soluble form is none the less absorbed wherever the leaf is touched by the ferruginous bouillie. Chlorotic plants after several sprayings with this bouillie show green places at all points of contact. Nevertheless, the effect of these bouillies is *nil* if a strong dose of sulphate

of iron be not used. Whilst 1 per cent solutions of ferrous and ferric salts produce a stimulating effect on the plant, it requires 3-15 per cent of hydrated oxide of iron to produce the same effect, and it is necessary to apply these bouillies in sprayings several times a year. Lagarrique recommends to apply them every fifteen days. Several scientific observers have imagined that the stimulating effect of copper bouillies was to be attributed to the sulphate of iron present in greater or less amount in commercial sulphate of copper. In their opinion pure copper sulphate free from iron would have no salutary effect on the plant and could not be absorbed by it without injuring its health. The mixed bouillies of sulphate of iron and sulphate of copper recommended to accentuate the stimulating effect of bouillie bordelaise are:—

Pellegrini's, 1 lb. of blue vitriol, 1 lb. of green vitriol, 1 lb. of quicklime in 10 gallons of water. *Aderhold's*, 19 lb. of blue vitriol, 1 lb. of green vitriol, 20 lb. of quicklime in 100 gallons of water. *Sorauer's*, 19½ lb. of blue vitriol, ½ lb. of green vitriol, 20 lb. of lime in 100 gallons. Goucdenovic, who examined the action of these bouillies compared with those of pure sulphate of copper, found they were in no way superior as stimulants. One cannot understand in fact how a copper bouillie containing only 0·1-0·05 per cent green vitriol as hydrated oxide of iron can produce any stimulating effect when it is necessary to use 3 per cent of this oxide to produce the same effect with a ferric bouillie.

Action of Ferric Bouillies on Fungi.—The hydrated oxide of iron has no pronounced toxic action on the spores of fungi, and cannot in any case replace the hydrated oxide of copper in the struggle against cryptogamic disease. Although green vitriol be ten times less toxic for plants and fungi than blue vitriol, these relations do not exist between the corresponding iron and copper oxides. The numerous experiments to replace the costly cupric bouillie by bouillies with a hydrated oxide of iron base have given no result in the struggle against plant diseases due to parasitic fungi.

Phytophthora infestans, De By. (potato disease).—Iron bouillies have been more especially tried against this disease as substitutes for bouillie bordelaise. Giltay's experiments with a bouillie of 1 per cent green vitriol and ½ per cent of lime gave negative results. Sempotowsky tried stronger bouillies, but they had no more effect in diminishing or preventing the potato disease than the 1 per cent solution. Steglich also points out the bad effects on potatoes by treatment with iron bouillies containing 2-4 per cent of sulphate of iron.

Gloeosporium ampelophagum, Sacc. (grape rot).—Pellegrini obtained very good results in overcoming this disease with a bouillie consisting of 1 lb. of blue vitriol, 1 lb. of green vitriol, and 1 lb. of lime in 10 gallons of water.

Entomosporium maculatum, Lev. (spots of the leaf of the pear-tree, leaf scald).—Fairchild did not cure this disease by using a bouillie consisting of 0·6 per cent of hydrated oxide of iron prepared by precipitating green vitriol by caustic potash.

66. Sulphide of Iron (Ferrous Sulphide), FeS_2.—**Preparation.**

—By precipitating green vitriol by an alkaline sulphide. It forms a black gelatinous powder.

Properties.—Insoluble in water. Readily oxidizes in air.

Use.—Galloway tried against the rust of oats and wheat a bouillie of sulphide of iron obtained by precipitating 28 lb. of green vitriol by 24 lb. of liver of sulphur and thinning down the whole to 100 gallons. In spite of four sprayings, 6, 16, 20 June and 5 July, the result was negative, as might have been foreseen, looking to the insolubility of iron sulphide in atmospheric agents. Fairchild used this bouillie against *Entomosporium maculatum* (spots of the leaf of the pear-tree, leaf scald) and *Phyllosticta sphæropsidea*, E. and E. (spots of the leaf of the chestnut). The experiments showed that it was not capable of circumscribing or preventing these diseases, but that it caused serious damage to the leaves of the plants treated.

67. Iron Chloride, $Fe_2Cl_65H_2O$.—**Preparation.**—By dissolving iron in *aqua regia* or by passing a current of chlorine into a solution of protochloride of iron (ferrous chloride). The solution concentrated by boiling yields on cooling orange red crystals of ferric chloride.

Properties.—Very soluble in water. Its solutions coagulate blood and act as hemostats in medicine.

Use.—Galloway found a 1 per cent solution sprayed every ten days on wheat fields preserved them against rust. The treated plot showed no rust. The check plot showed twelve plants attacked. This action, which greatly resembles the action of soluble salts of copper, is apparently only due to the exceptional vigour of the cereals due to this treatment. Moreover, Hitchcock and Carleton have shown that a 1 per cent solution of perchloride of iron can only interfere slightly with the vitality of the spores of *Puccinia coronata*, Corda (crown rust of oats), and Wuthrich has proved that it requires a 10 per cent solution of perchloride of iron to kill the uredospores of *Puccinia graminis*, Pers. (linear rust). At the same strength as the persulphate of iron, ferric chloride is directly assimilable by the leaf and acts as a powerful stimulant of the vital functions of the plant. As a tonic, perchloride of iron may be of use in the struggle against the diseases of plants, but it cannot be ranked as an anticryptogamic substance capable of killing the spores of fungi.

Entomosporium maculatum (spots of the leaf of the pear), *Phyllosticta sphæropsidea*, E. and E. (disease of the leaf of the chestnut).—Fairchild used to combat these two fungi a mixture of 1 per cent of ferric chloride, 1 per cent of carbolic acid, even 0·5 per cent of each of these substances. Without any action on the development of these diseases, the two mixtures seriously scorched the leaves.

Chlorosis.—Stevignon made comparative trials with perchloride of iron and green vitriol, and found that the action of the perchloride was much more rapid than that of the sulphate. He obtained the best results by making incisions in the bark of the stocks, and coating the wounds with a 40 per cent solution of perchloride of iron; fifteen days after treatment the chlorotic vines were quite green. Comparative trials with hydrochloric acid itself have shown that it is the iron which is the active element and not the hydrochloric acid.

68. Sulphate of Iron, syn. **Green Vitriol,** $FeSO_47H_2O$.—**Preparation.**—(1) By roasting iron pyrites and lixiviating the product. (2) By slow oxidation in the air of pyritic shale. (3) By dissolving iron turnings [or scrap iron] in dilute sulphuric acid. By concentrating the solution to 40° B., it abandons green crystals responding to the formula $FeSO_47H_2O$.

Properties.—*Solubility,* 100 parts of crystallized green vitriol dissolved in 143 parts of water at 15° C., and in 30 parts of water at 100° C. To prepare solutions of green vitriol it is best to use boiling water; they must then be kept in closed vessels, for the salt is readily converted into a slightly soluble basic sulphate of sesquioxide of iron in contact with the air; green vitriol has a styptic, astringent taste.

Action of Green Vitriol on Green Plants.—Iron is invariably present in all green plants, but often in very small quantity. As to its distribution in the plant, it may be said to be present more especially in all the green parts, without being, however, entirely absent in other parts of the plant. Iron may be considered as necessary to plants as to man and animals. Its absence produces a pathological condition known as *chlorosis.* Culture experiments have shown that the plant cannot develop itself normally in absence of iron. The necessary quantity is very small, and 2-5 milligrammes suffice for a cereal plant (Knop). Sachs induced artificial chlorosis by cultivating plants in a soil in which iron was excluded. Experiments made in nutritive solutions show that the seed may germinate and the young plant grow normally in the absence of iron; the small quantity of iron present in the seed amply suffices in the beginning to allow a normal growth, but later on a fresh portion of iron becomes indispensable or the plant gets into a bad state. Knop proved that the amount of iron in a gland was sufficient to prevent chlorosis of the young oak for two years. The plants which succeed best are those treated with a 0·15 per cent solution of green vitriol; a stronger dose than 0·2 per cent is often injurious. The absence of green in plants deprived of iron has given rise to the idea that iron takes part in the formation of that colour, but we are far from knowing exactly what is its rôle in the formation of chlorophyll. Formerly it was believed that iron entered into the composition of chlorophyll as in the hæmoglobin of the blood, but this opinion is not entertained at the present time. The analysis of purified chlorophyll and the demonstrations of Armand Gautier and Hoppe-Seyler prove, in fact, that iron does not enter into the chemical composition of the green parts of plants. Certain recent discoveries, however, lead us to suppose that there exists along with chlorophyll substances of analogous composition containing iron. Iron is not only indispensable to the normal formation of chlorophyll, but it has a favourable action generally on the life of the plant. Green vitriol applied to the surface of a green orange becomes yellow by the absence of iron salts and restores to it its primitive colour. Brogniart, Gris, and Treviranus have already described this and produced drawings made on the leaves to show the local action of green vitriol. Millardet and Knop believe that like blue vitriol green vitriol acts without penetrating the leaf, for

they were not able to find ponderable quantities in the organs cured. Of a contrary opinion Dufour describes the absorption of these salts by the surface of the leaf, and Weiss and Wiesner have shown that iron which enters into the plant exists there in organic combination which may have escaped Millardet and Knop. Frank, Kruger, and Vedrosi regard green vitriol as equal to blue vitriol as a stimulant of the plant, and believe that a very small dose suffices to produce a visible and salutary effect. These two salts seem to act in quite the same manner on plants with this difference, that copper salts possess an action ten times stronger than iron salts taking into account their different chemical equivalent. Shrubs which annually undergo the classical treatment with bouillie bordelaise, likewise those which are treated with solutions of green vitriol, acquire a greatly increased vitality which increases assimilation and a longer vitality which enables trees to preserve their leaves in autumn much longer than those untreated. These facts prove that iron is the active chemical agent in the formation of chlorophyll, stimulating its functions, and in that way also it becomes the indirect provider of starch, sugar, and cellulose for the plant. Without iron, on the other hand, the plant eventually dies because assimilation of carbonic acid becomes impossible. The rôle of iron therefore seems analogous to that of potassium, the absence of the latter element also inducing the anæmia of plants. The substitution of iron for potassium according to Griffiths' experiments would be very advantageous in the struggle against the cryptogamic diseases of plants. Potash is very favourable to the development of fungi, whilst green vitriol is injurious. The substitution of green vitriol for potassic manures whilst giving the same physiological results would have the effect of circumscribing the cryptogamic diseases of plants. Desjardin had already observed the great resistance of plants treated with green vitriol to disease. Chavie-Leroy certifies that the simultaneous use of green vitriol and gypsum preserves grain crops from rust and laying; it diminishes ergot, the fall of the flower of the vine, stops the canker of apple and pear trees, and causes the gum of stone-fruit trees to disappear. Like gypsum, green vitriol used in the soil acts on the latter from a physical and chemical point of view. Boussingault agrees with Sachs, Stohmann and Knop (1) that it oxidizes the organic matter of humus and hastens its decomposition; (2) that it fixes ammonia in the soil; (3) that it aids the plant to absorb the phosphoric acid in the soil. Thenard and Joulie state that phosphate of lime is converted in the soil, in contact with oxide of iron, into phosphate of protoxide of iron soluble in water charged with carbonic acid; the ferric phosphate formed would afterwards be reduced by the organic matter. In 1859 Knop was already convinced of the action of iron as a vehicle for phosphoric acid. Like gypsum, green vitriol effects a radical change in the soil by the decomposition of the insoluble minerals which contain potash. Green vitriol forms an equivalent of a soluble potash salt and thus renders the richness of the soil available for the plant. It follows that green vitriol having always a beneficial action on crops is thus capable of increasing the yield and that chiefly as regards plants to which potash is necessary. Where carbonate of lime is the

cause of the chlorosis, green vitriol has a very intense ameliorative action and must be used in large doses. It acts on the soil by destroying the soluble carbonate of lime and on the plant by revivifying the juices and imparting to them new vigour, for the excess of carbonate of lime exhausts the acid juices of the root which then cease to act. It follows from Vernet's experiments that the use of green vitriol in 5 per cent solution with 5 per cent of sulphuric acid gives still better results; this acid decomposes the carbonate of lime and enables the green vitriol to come in contact with the roots as such. Chlorosis was in this way made to disappear in soils containing 19-25 per cent of carbonate of lime. As to the form under which the iron ought to be applied to the roots it is not definitely settled, neither do we know what salt of iron is most easily assimilated by plants and under what form the iron is conveyed the most easily from cell to cell. Ferrous salts [of which green vitriol is one] are always, it is supposed, converted into ferric salts in contact with the oxygen of the air in the soil. However, many facts appear to contradict this opinion; the most different ferrous and ferric salts are capable of remedying the pathological condition produced by a deficiency of iron. These salts spread by copious spraying on the roots act before the ferrous salts (green vitriol, etc.) can have had the time to be converted into ferric salts. If the ferric salts are more active on the other hand, the ferrous salts render the same service in a longer time. It must be mentioned that green vitriol ferrous sulphate must be used in a much more dilute condition than ferric sulphate. The form most favourable for artificial cultures is the phosphate of iron which the roots assimilate after rendering it soluble. The following observation speaks in favour of the absorption of iron under the form of ferrous salts: plants which live in marshes, rich in green vitriol, possess great accumulations of iron as ferric oxide in certain of their organs. (*Trapa natans* contains in its ash 68·6 per cent of ferric oxide.) These deposits cannot be otherwise explained than by the precipitation by oxygen of soluble ferrous salts being conveyed through the plant and so converted into insoluble ferric salts. According to Mokrzecki it is possible that green vitriol may be absorbed by the plant, and conveyed by the sap. The rapid and radical cure of chlorosis by injection into the trunk of dilute solutions of green vitriol which in no way affect the good working of the circulation is a convincing proof.

It follows, therefore, that iron may be supplied to the plant under any form, and that ferric salts as well as ferrous, organic and inorganic salts of iron are capable of curing chlorosis. (Gris has shown that the sulphate, tartrate, malate, and acetate of iron in the dose of 0·5 per cent when they are used in sprayings on the leaf produce an analogous effect.) It must be admitted, in fact, that the roots can convert the iron into a compound fit to circulate through the organs of the plant, and to produce the remarkable physiological effects described above. If a certain dose be exceeded the iron becomes injurious, if given in excess it is mortal. Different plants behave very differently with the same dose of iron. Whilst certain plants suffer with a dose of 0·05 per cent of green vitriol in an artificial culture medium, trees may sup-

port injections of a 0·25-0·5 per cent solution of the same substance. The injurious action of green vitriol depends greatly on the nature of the plant to which it is applied. Aqueous plants very fond of water are much more sensitive than plants not fond of water. Mosses, for example, feel the action of green vitriol much more than cereals. A strong dose of green vitriol has a specially injurious action on the vital functions of the plant; thus Mayer found that, used for grain crops, it hindered the grain from forming in the ear.

TABLE XXI.—*Showing the Number of lb. of Green Vitriol which Wheat, Rye, Barley, and Oats, respectively, can bear per 1600 lb. of Soil.*

Grain Crop.	*Lb. of Green Vitriol.*
Wheat	4
Rye	10
Barley	20
Oats	20

Whilst barley is unable to form its grain if the dose of green vitriol contained in the soil is above that given in Table XXI, oats resist better. The injurious action of green vitriol is explained by the fact that in presence of tannins and certain other analogous products it is readily decomposed into insoluble organic compounds and sulphuric acid. The latter causes at a certain concentration the corrosion of the cellular tissue and disturbs the osmotic phenomena of the cell-walls. Deherain and Grandeau in France, Wrightson, Griffiths, and Munro in England, have shown that 60 kilogrammes per hectare ($\frac{1}{2}$ cwt. per acre) may always be used with advantage, whilst a dose of 250 kilogrammes per hectare (2 cwt. per acre) was often injurious.

Action of Green Vitriol on Fungi.—Iron is not only necessary to green plants, but a small quantity of this product would also seem to be required by parasitic plants with no chlorophyll. The latter are, however, more sensitive to green vitriol, which, like blue vitriol, is often a violent poison for them. As to spores it has been shown that the injurious action is connected with the penetration of the green vitriol through the exterior membrane. If this penetration does not occur the action is *nil*, if it occurs vitality is arrested. Iron like copper may be found in the interior of the spores by means of certain reagents. To determine if green vitriol has penetrated the spores, these, after steeping in the green vitriol solution, are washed for fifteen minutes, then they are placed in a bath of yellow or red prussiate of potash and a little hydrochloric acid. If the iron has been absorbed the spore becomes blue. Wuthrich found this absorption in all cases where the spore was dead after immersion in vitriol. According to the experiments made up to now on fungi, green vitriol acts identically with blue vitriol, which, however, is the more energetic. Wuthrich concludes that the doses of green vitriol and of blue vitriol which produce the same action on the spores of different fungi are proportional to the chemical equivalents of these salts, green vitriol, these proportions preserved being ten times weaker.

The following are the amounts of green vitriol and blue vitriol required to stop the growth of spores :—

TABLE XXII.—*Showing the Strength of Solutions of Blue and Green Vitriol Required to Kill Spores of*

	Green Vitriol, Per Cent.	*Blue Vitriol, Per Cent.*	
Phytophthora infestans . .	0·139	0·0125	Wuthrich
Peronospora viticola . .	0·139	0·0125	,,
Ustilago carbo . . .	1·39	0·125	,,
,, ,, . . .	5 00	0·5	Boiret
Puccinia graminis . . .	1·39	0·125	Wuthrich
Claviceps purpurea . . .	13·9	0·0125	,,

From the above table spores have not the same resistance to green vitriol. Whilst some are very sensitive others are very resistant, and support doses poisonous to certain green plants. The quantity required to destroy some of them is so great that there can be no question of their destruction on the nurse plants by green vitriol, for the latter plants would be killed as well as the parasites. That is why blue vitriol can never be replaced by green vitriol in fighting the cryptogamic diseases of plants. When the parasites can be attacked without injury to the plant, green vitriol is an excellent cryptogamic ; its use in the treatment of anthracnose is a striking example. Although green vitriol be less utilized in agricultural medicine than blue vitriol, its use against the cryptogamic parasites of our cultivated plants is a necessity in many cases. Where its action is not sufficient to destroy the spores of the fungi by imparting greater vigour to the plant, it enables it to contend more readily against its parasites. Galloway has shown that sprayings with green vitriol absolutely incapable of killing the spores of rust, nevertheless almost entirely eliminated this disease from the grain crop. The same applies to the *Claviceps purpurea* (ergot), a fungus reputed to have a very great resistance to green vitriol, the ravages of which may, however, be considerably diminished by spraying therewith. Each time that green vitriol has been used as a manure for cultivated plants, or sprayed thereon, improvement has resulted as well as a considerable diminution in diseased plants.

The Action of Green Vitriol on Insects.—Green vitriol has no action on hard-skinned insects, for it is not absorbed so long as the skin is intact (Parisot). The mucous membranes, on the other hand, may absorb poisonous doses ; taken through the mouth iron salts are violent poisons. Amongst mammals a small amount of iron salt may cause death by stopping the action of the heart (Rabuteau). Ferric salts are more dangerous than ferrous salts, because they coagulate the soluble albumen and thus arrest the circulation of the vital liquids. Ferric salts ought, therefore, to be regarded as violent poisons. The action on insects does not make itself felt unless absorbed by the mouth, in eating the leaves sprayed with iron salts.

Use of Green Vitriol. — From time immemorial ferruginous manures were used to improve crops. The Romans knew the good effect of iron and utilized as a manure certain soils, rich in oxide of

iron, still in use in Italy under the name of "Terra rosa". In Champagne, likewise, pyritic shales have been used in vineyards for centuries. In the North of France, Picardy, Ardennes, Normandy, and in Flanders, there are used for the same purpose the ashes of Picardy which contain much iron pyrites. These are not only used to double the yield of meadows but also to strengthen cereals. Astonished at the results obtained by the use of these ferruginous manures, Eusèbe Gris, Professor of Chemistry at Chatillon sur Saone, tried to ascertain the cause. His experiments showed that the green vitriol formed by the slow oxidation of the pyrites in the soil was the active cause. As far back as 1840 he recommended green vitriol to improve crops and to contend against chlorosis. The researches of his son, Arthur Gris, and Knop enabled the function to be explained and extended its use. Gradually it entered common use to contend against the cryptogamic diseases of plants. Green vitriol may be used in different ways; in cultivation on the large scale it is spread as crystals, or in 3-5 per cent solution, by watering carts; it may also be sown by hand as a fine powder intimately mixed with dry earth. To cure trees of chlorosis and parasitic diseases, the incorporation of green vitriol in the soil may be replaced by spraying on plants or even by injection into the trunks of the trees. Used in that way the action of green vitriol is felt much quicker than when it is absorbed by the roots.

Use of Green Vitriol as a Weed-killer.—All plants being more or less sensitive to the action of green vitriol, it is evident that by using a determinate quantity of this salt all the plants which have a less resistance can be eliminated from a given crop. Thus grain crops possess a surprising resistance to this product, and it is possible to destroy all the weeds in a field of grain without injuring the crop. Steglich has treated different adult plants with a 20 per cent solution of green vitriol and obtained the following results: Grain crops are not attacked; peas, trefoil, linseed, charlock suffer from this treatment; potatoes, beets, haricots, lupins are greatly damaged; mustard is killed. Stender confirms Steglich's results. He treated cultivated plants with a 15 per cent solution of green vitriol by spreading it at the rate of 4 hectolitres per hectare (35·2 gallons per acre) and found no damage on cereals, blue lupin, red trefoil, colza, poppy, and carrot, but moderate damage on peas, flax, and serradelle (? saw wort); finally much damage on millet, rape, white mustard, potatoes, and beet. Twenty-five per cent solutions of green vitriol destroy almost all weeds; however, horse-tails, comfrey, nettles, and carex resist perfectly. The action of green vitriol solutions is especially deadly to young plants when they have only three to four leaves; if the adult plants resist concentrated (15-20 per cent) solutions, young plants cannot stand much smaller doses. Strong solutions of green vitriol are not, therefore, necessary when used rationally, and, as Dumont found, a 5 per cent solution suffices in most cases, especially when it is a case of destroying young mustard. The older the plant to be destroyed the stronger should be the solution of green vitriol; thus mustard in flower requires a 10 per cent solution, adult mustard a 15 per cent solution. Gwallig recommends for the destruction of this plant a 7-10 per cent solution.

Linet agrees. To destroy charlock, Hitier estimates that 10 hectolitres of a 10 per cent solution per hectare suffice (88 gallons per acre suffice). Weiss also recommends this same quantity, but of 10-15 per cent strength. Schultz concluded after numerous tests that it was necessary to use 15 per cent solutions, although young weeds already suffer with a 2-3 per cent solution. It is necessary to apply this treatment when the plants have only three or four leaves; it is true that cereals suffer slightly when young even when only a 7 per cent solution is used, but they soon revive and only grow afterwards with increased vigour. To destroy young charlock and mustard 5-10 per cent solutions suffice, but to destroy all weeds 15 per cent solutions must be used. Wallflower requires a 10 per cent solution in the beginning of vegetation. Before spreading green vitriol on a field the age and sensitiveness of the plant must be taken into account. It is best to proceed thus: The solution of green vitriol is conveyed to the neighbourhood of the field and sprayed by a spraying machine or a watering-cart. The best time to treat weed-infested fields is just before the weeds rise up into stems, i.e. when they have four to six leaves. It is well to spray in fine weather, which by concentrating the solutions on the surface of the leaves increases the effect. To free fields of grain chemically from charlock, advantage may be taken of the dew to spread finely pulverized green vitriol at the rate of 200-300 kilogrammes per hectare (176-264 lb. per acre). If rain intervenes after green vitriolizing, its effect is lessened or destroyed. But even in that dose and under that form green vitriol is not so efficient as a 4 per cent solution of blue vitriol at the rate of 800-1000 litres per hectare (70-88 gallons per acre). A man is capable of vitriolizing a hectare ($2\frac{1}{2}$ acres) a day; 10 hectolitres (220 gallons) of green vitriol solution, that is to say, 100 kilogrammes (2 cwt.) of this salt suffice per hectare (88 lb. in 88 gallons per acre). The total cost of the treatment may be estimated at 10 francs (8s.) the hectare (say 3s. $2\frac{1}{2}$d. the acre). There must be no hesitation in applying this treatment, which while freeing the fields from encumbering weeds supplies it with a new element as an aid to growth. From Steglich's comparative trials green vitriol has no advantage over such metallic salts as muriate of potash, nitrate of soda, and sulphate of ammonia, which whilst destroying weeds are good manures. However, we believe, that green vitriol is superior to these salts by its anticryptogamic properties.

Destruction of Moss.—1. *On Meadows and on Lawns.*—Mosses which invade all lawns, and diminish the yield of many meadows, may be readily destroyed by green vitriol. Their affinity for water is such that they absorb in large quantity the green vitriol distributed in solution. The extreme limits to employ per hectare are 250-500 kilogrammes of green vitriol (2-4 cwt. per acre). It is well to spread the distribution over several applications, especially when the meadow is badly choked up with moss. Noffray advises not to go beyond 100-150 kilogrammes per hectare (88-132 lb. per acre) in each of these applications. If green vitriol is used in crystals, it is necessary to choose fine weather to spread it after a strong dew, during or after rain. If green vitriol is used in solution in watering-carts, any time

may be chosen ; however, the best result would be obtained by applying the treatment after cutting the grass. Mosses infest poor and moist soil; after their destruction by green vitriol the cause of their presence should be obviated by manuring and draining [and liming].

2. *On Trees.*—To free the trunks of trees from mosses and lichens, which are so many refuges for parasites, they are scraped with the decorticator-moss-eradicator, then the trunk and branches are coated with a solution of green vitriol. The stronger the solution the better, but the strength of the green vitriol may be considerably reduced by adding a corrosive acid, such as sulphuric acid; in such conditions a 10 per cent solution of green vitriol containing 2 per cent of sulphuric acid acts as well as a 40 per cent solution of green vitriol. By adding 2 per cent of blue vitriol to this solution, the tree is freed from all spores of fungi.

3. *On Roofs.*—A 10 per cent solution of green vitriol spread on moss-covered roofs completely destroys the moss. But green vitriol cannot be used where there are zinc gutters, for the latter will be corroded by contact therewith.

Destruction of Dodder.—Dodder is a plant without chlorophyll, which, like fungi, is more sensitive to the action of iron than green plants. But if the filaments of the young plant do not resist 2 per cent solutions, on the other hand a 10 per cent solution is required to kill the adult plants, which often kills or injures the nurse plant. Schribaux's tests have shown that dodder seeds, owing to their thick tegument, resist 20 per cent solutions of green vitriol, and that even after steeping for fifty days their vitality is not lessened. Immersion in water for fifty days: 19 per cent germinated. Immersion in 20 per cent solution of green vitriol for fifty days : 12 per cent germinated. Dodder specially invades trefoil and lucerne fields, plants equally sensitive to 10 and 20 per cent solutions of green vitriol; needless to say the treatment should be applied before fructification and should not extend over the whole field. It suffices to treat the parts attacked. Stronger solutions of sure effect can thus be used. By sacrificing a few square yards of the crop the spread of the plague can be averted. The following is the best method of working : After mapping out the dodder spots, comprising within the surface to be treated a radius of a metre beyond that where the filaments are apparent, the spots are cut with the scythe. It suffices then to water the diseased spots with a 2 per cent solution of green vitriol if the treatment be carried out in May; on the contrary, if in July a 10 per cent solution will be required. Needless to say if one watering be not enough, the operation is repeated a few days afterwards, and watering must be copious so as to reach the matted filaments. Ponsard and Clerc advise this treatment to be done in the spring.

Use of Green Vitriol to Combat the Diseases of Plants.—*Chlorosis.*—In certain conditions unfavourable to the plant, chlorophyll, the active agent of assimilation, does not develop normally. A condition of languor follows, which is manifested by a yellowish or reddish coloration of all the green parts of the plant. This pathological condition is known as *jaundice,* when it is caused by a want or excess of

water; *etiolation*, when it is produced by the want of light; *chlorosis*, when it is due to the want of iron. (This condition has some analogy with the anæmia of man.) But the absence of potash may induce the same phenomena. An excess of carbonate of lime in the soil,[1] insufficient nourishment, a defective condition of the roots,[2] a pathological condition of the whole plant,[3] insufficient heat, are so many causes which may produce a chlorotic condition of the plant. Hence it is easy to understand that iron cannot always remedy these diseased conditions. It can only be of real service where the chlorisis is due to a want of iron, or to an excess of lime,[4] and of minerals rich in unassimilable potash. In jaundice and etiolation it would be of no use. In the case of a tree attacked by chlorosis, the cause must above all be carefully determined and iron only used well to the purpose. Where chlorosis is due to a want of iron, the use of iron salts is to be prescribed, and they will yield always a green coloration in a short interval as well as give new vigour to the plant. The dose to use varies in different cases. There are numerous methods which are more or less effective, and which act more or less rapidly.

1. **Application of Green Vitriol to the Soil.**—The most usual method is to spread green vitriol in crystals around the tree in doses of 1-2 kilogrammes (2·2-4·4 lb.) per tree, and preferably after a heavy rain. The dose is of no great matter; an excess of green vitriol would not injure the tree, as it is converted into insoluble derivatives in the soil. Used thus its action is slow but durable. To get a more prompt effect it is better to act thus: A circular trench is dug round the tree, at a distance from the trunk, varying with its size, from 20-40 inches and a width of 8-12 inches. After well watering it, 1-2 lb. of green vitriol in crystals are sprinkled into it, or better still, a mixture of manure and green vitriol in powder; the soil is filled back into the trench and copiously watered. It is preferable to dig out a basin around the diseased tree and to fill in 10-20 litres (2·2-4·4 gallons) of a 10 per cent solution of green vitriol (Tomé) or a 5 per cent (Guirand). By repeating this treatment several times, every eight days, the cure will be rapid and complete, and the action will be more prompt as the tree is more in sap. The dose to use which in certain cases may be very weak (Sorauer advises a solution of 100 grammes of green vitriol, 30 grammes of saltpetre, and 20 grammes of phosphate of potash per tree), ought, on the other hand, to be very strong if the soil is calcareous. When carbonate of lime is the predominating cause of chlorosis, as is the case with trees with seed pips, such as the pear, and more especially the vine,

[1] Viala has shown that a vine in pot treated with 2 kilogrammes (4·4 lb.) of lime became chlorotic in forty days.

[2] Dementjew having found different acari on the roots of trees attacked by chlorosis attributed that disease to their presence.

[3] Roux believes he observed micro-organisms in plants attacked by chlorosis.

[4] According to Dementjew's experiments an excess of carbonate of lime would only induce chlorosis when there was a lesion of the roots, a healthy root being only able to absorb a normal amount of lime; barium chloride as well as common salt produce chlorosis under like conditions; it would thus be the acari which he found on the roots which by producing lesions were the prime cause of the chlorosis of the tree.

the amount of green vitriol used must be greater the richer the soil is in carbonate of lime. If the normal quantities to be spread on the soil of a vineyard generally vary between 300 and 1500 kilogrammes per hectare (264-1320 lb. per acre), these quantities should rise to 4-8 metric tons (3520-7040 lb. per acre) when the soil is highly calcareous (Viala). This dose is spread in winter on the soil and buried by hoeing. Vernet recommends, so as to diminish the dose of green vitriol and to increase the action, the use of a 5 per cent solution acidulated with 5 per cent of sulphuric acid. At the rate of 2 litres per stock the results were perfect, and did not injure the roots. Sulphuric acid by converting the carbonate of lime into sulphate of lime lets the green vitriol penetrate more easily as far as the roots, and prevents its conversion into insoluble carbonate of iron without immediate effect on the plant. The treatment of chlorosis by vitriolizing the roots tends to disappear because it is slower than treating the aerial part of the plant with green vitriol solutions.

2. **Use of Green Vitriol on the Aerial part of the Plant.**—(A) **As Spray.**—Eusèbe Gris was the first to find that by spraying the leaves of a chlorotic tree with a 0·5 per cent solution of green vitriol the leaves rapidly assume a green coloration, first on the spots in contact with the green vitriol, then over all their surface. This process gives much quicker results than when the iron is absorbed by the roots, but the effect is also more ephemeral, unless spraying is repeated several times a year. It then forms an excellent method against chlorosis. However, like blue vitriol, green vitriol in decomposing liberates sulphuric acid injurious to plants and thus produces corrosions and scorchings which only the simultaneous use of lime can remove. The amount of green vitriol to be used in spraying must, therefore, be well estimated so as not to exceed the amounts recognized as harmless. Two per cent solutions burn the leaves treated (Dufour, Sagnier, and Mohr). Brunet and Delacharlony found that the vine did not suffer in contact with a 2 per cent solution, but they recommend not to use the latter except on adult leaves. In spring a 1 per cent solution must do.

(B) Use as a Coating.—This process is based on the absorptive power of plant tissues in contact with solutions of metallic salts. Rassiguier tried to make a radical cure of chlorosis of the vine by introducing green vitriol in a strong dose into the sap. After preliminary pruning in autumn at the fall of the leaf whilst there is still a movement of the sap, the sections are coated with a 40 per cent solution of green vitriol; a large portion of the iron is then absorbed. In the spring the pruning of the vine is completed. This process has given marvellous results, especially on vines growing in soils very rich in lime, and it has replaced the process which consists in spreading on the soil strong doses of green vitriol in the form of crystals. But it is recognized that poisoning occurs with 50 per cent solutions, but not with 40 or even 30 per cent solutions which produce the same salutary effect. Thus Guillon recommends the use of 20 or 25 per cent solutions for young and 30 per cent for adult vines. This method which has numerous partisans has been used with the fourfold end in view of (1) curing chlorosis; (2) combating anthracnose; (3) de-

stroying cryptogamic germs; and (4) preserving vines from frost. But to attain this end, instead of only coating the sections the whole stock must be coated from top to bottom with a 30-40 per cent solution of green vitriol. This treatment, which is done in this case in the autumn, retards from ten to twelve days the exit of the buds and may thus preserve the vine from late frosts. Used on the large scale in Cognac and Charente this process gives most precise and satisfactory results. André has adapted the Rassiguier treatment to fruit trees. After autumn pruning he coats the same day the sections and all the wood with a 30 per cent solution of green vitriol. This process, very effective on young trees attacked by chlorosis, is not energetic enough for large trees, on which it is necessary to decapitate the branches and to make slight incisions in the bark of the base of these branches. By means of a brush a 30 per cent solution of green vitriol is caused to penetrate as far as the sapwood. These coats should be applied at intervals of eight days. Favourable results were got chiefly on cherry-trees, pear-trees, and peach-trees; the yield in fruit is much increased, and amongst the latter the rust completely disappears. Green vitriol can thus be entrained by the sap without injuring the plant. Very interesting trials by Mokrzecki conducted thus confirm this fact: He pierced one or several holes in the trunk of the tree and there introduced green vitriol in crystals, then closed the holes with mastic. An average dose of 12 grammes suffices to suppress chlorosis.

(C) Use as an Injection in the Trunk.—The satisfactory results obtained by the extra-racinary nutrition of trees and by the injection of nutritive salts into the sapwood of the trunk induced Mokrzecki to hope to cure chlorosis by injection of solutions of green vitriol into the sap. He pierced one or more holes of 1-1·75 centimetres ($\frac{2}{5}$-$\frac{7}{10}$ inches) in diameter in the trunk and injected 12 grammes of green vitriol in 0·05-0·25 per cent solution. So that the solution may be entrained by the sap it is of importance to prevent access of air [1] into the hole during the time it is being pierced. To accomplish this it is necessary to proceed as follows: The point of the centre-bit is passed through a metal tube which communicates by an india-rubber pipe with the reservoir containing the green vitriol solution. By working the centre-bit the liquid forthwith fills the space drilled out and thus prevents the access of the ambient air. The reservoir is hung to a branch and the liquid thus introduced under a certain pressure. The holes are pierced through the sapwood. A tree with a diameter of 20 centimetres (8 inches) is capable of absorbing 8 litres ($1\frac{3}{4}$ gallons) in twenty-four hours. As soon as the operation is finished the hole is refilled with mastic. The most favourable time for this work is the months of March, April, or May, when the sap is in motion. Trees attacked with chlorosis show from the fourth day a greener colour in their leaves; in ten days chlorosis is no longer to be seen, and in three weeks the leaves are deep green. Trials made on 840 trees leave no doubt of the efficiency of this treatment. During his experiments Mokrzecki also observed that all the organs of

[1] The appliances formerly used by Bouchery, Hartig, Pichi, and Berlese allowed air to penetrate which prevented the absorption of the liquid.

these trees were influenced favourably, the buds were more vigorous, fruits more numerous, growth more rapid, and that especially if the treatment was combined with extra-racinary feeding, which finds many partisans nowadays. The same observer has pointed out that kermes such as *Diaspis fallax*, Horv., of the pear-tree and *Mytilaspis pomorum*, B., of the apple-tree were much less numerous and even disappeared from the trees treated with green vitriol. It is the same as regards the *Gum* and the *Fusicladium*.

Cryptogamic Diseases of Plants.—Attempts have been made to combat by green vitriol and green vitriol bouillies diseases capable of being restricted by blue vitriol and cupric bouillies. Green vitriol being much cheaper than blue vitriol this substitution would have had great pecuniary advantage. Unfortunately, the dose to use being ten times larger to produce the same effect, this advantage disappeared, and the use of green vitriol was restricted to the parts of the plant which bear this treatment. Used in the same strength as blue vitriol in spraying leaves attacked by various diseases it does not produce the same salutary effect. However, its action is not *nil*, and its stimulating power on the vital functions of the plant causes the latter to suffer less from the attacks of parasites, and often prevents their spreading.

Potato Scab.—Nijpels found that green vitriol spread on potato fields appreciably diminished the scab of the tubers without completely preventing it.

Bacillary Gum of the Vine (Mal Nero).—The only remedy capable of stopping the spreading of this disease is the radical removal of all the diseased parts (Prillieux and Delacroix). The wounds produced by pruning are coated with a concentrated solution of green vitriol and afterwards covered with a mastic. Where contagion is to be feared it suffices to coat the pruned sections to prevent the disease penetrating by the wounds. Meunier practised winter coating in his domain on every stock with a 50 per cent solution of green vitriol with 2 per cent of sulphuric acid. The effect was very satisfactory, the parts which had previously perished were cured and contagion avoided.

Bacterian Disease of the Mulberry.—Ruiter recommends the green vitriol treatment. As soon as a branch appears attacked it is cut off in the healthy part a few centimetres below the diseased spot. The cut branches are burned on the spot, then the pruned section is coated with a 45 per cent solution of green vitriol. Trees so treated grow in the same year of treatment vigorous buds and next year show no trace of the disease.

Phytophthora infestans, De By. (potato disease).—Green vitriol exerts an energetic action on the conidia of this fungus and a 1 per cent solution should produce an effect on the disease. Tried as substitutes for cupric bouillies, 1 per cent solutions of green vitriol used in two sprayings, the first on 18 June, the second on 15 July, produced no improvement. Petermann obtained by this process the following results: The plot treated gave 8·3 per cent of diseased tubers and 73 lb. of tubers. The check plot gave 11·3 per cent of diseased tubers and 102 lb. of tubers. A strong manuring with green vitriol in the spring will give such vigour to the potato plant that it will better resist this disease.

Peronospora viticola, De By. (mildew of the vine).—According to Wuthrich the spores the most sensitive to green vitriol are those of *Peronospora*. A solution of 0·0139 per cent kills the conidia after fifteen hours' immersion. The first trials to combat mildew were made in 1882. Millardet recommended a mixture of 4 lb. of green vitriol in powder, 20 lb. of green vitriol, and 20 lb. of plaster. A nursery of 2000 Jacquez attacked with mildew in the middle of June was treated 2 July in dry and hot weather. Success was complete; the young buds had not suffered, and they resisted the re-invasion of September. Reich found that the treatment for anthracnose is also a preventive of mildew. This treatment which consists in coating the stocks with a 25-50 per cent solution of green vitriol before the buds begin to unfold is used with success at Armeilliere against the *Peronospora*. This treatment is not always followed by the desired effect.

Ustilago (smut) and *Tilletia* (bunt).—Green vitriol has no action on the spores of *Tilletia levis* (Kuhn). Wuthrich showed by laboratory tests that a 1·39 per cent solution of green vitriol hinders the development of the spores of *Ustilago*, and a 13·9 per cent solution kills them. The trials of Boiret made by sowing the spores of brown rust on object glasses placed in a moist chamber at 18°-20° C. gave analogous results. A certain number of spores still germinate after an hour's immersion in a 5 per cent solution of green vitriol or after four hours' immersion in a 2 per cent solution, whilst the spores do not germinate in a 0·5 per cent solution of blue vitriol. Green vitriol has, however, been used for a long time to disinfect seed corn against smut and bunt. A 2-5 per cent solution of green vitriol was used in which the seeds were left to macerate for six to twelve hours, after which they were limed, then left to dry in the air. The results obtained were not very satisfactory. Mathieu de Dombasle artificially infected a portion of grain by agitation in a sack with the dust of brown rust, then he treated the infected grain with green vitriol, blue vitriol, and lime. After sowing he got the following results:—

TABLE XXIII.—*Showing the Results of the Experiments of De Dombasle on the Disinfection by Green Vitriol of Seed-Corn Artificially Infected on Purpose.*

	Percentage of Infected Ears.
	Per Cent.
1. Check plot, grain not treated	486
2. Grain sown after two hours' steeping in a 1·2 per cent solution of green vitriol	469
3. Grain sown after two hours' steeping in a 2·4 per cent solution of green vitriol	570
4. Grain moistened twenty-four hours before sowing with a 4 per cent solution of milk of lime	470
5. Grain steeped for one hour in a 1·2 per cent solution of blue vitriol	8
6. Grain steeped for twenty-four hours in a cupric bouillie of 10 per cent lime and 1·4 per cent blue vitriol .	2

Although the action of green vitriol on the grains of wheat is much less injurious than that of blue vitriol, this action, ten times less cryptogamicidic than the latter salt, forms no inducement to use it as a substitute. Used ten times more concentrated than blue vitriol its pecuniary advantages disappear. Henriot made interesting trials on the pickling of seed-wheat. The seeds steeped for twenty minutes in a 1 per cent solution of green vitriol germinated quicker and more uniformly, and produced more vigorous plants, than the unpickled seeds sown in the same conditions. Besides the plants seemed less sought after by insects than the check plants. On peas the increased yield was 100 grammes more per square metre. Turnips also gave an increased yield, and were not attacked by the fly (altises). Henriot recommends pickling cabbage seed, radish seed, turnip seed, peas, haricots, salad, etc., seeds to secure quicker germination and a bigger yield.

Puccinia (rust).—The uredospores do not germinate after fifteen hours' immersion in a 13·9 per cent solution of green vitriol. The æcidiospores, more sensitive, do not germinate after immersion for the same time in a 1·39 per cent solution (Wuthrich). Used by Galloway to combat rust of winter wheat, green vitriol was found incapable of restricting that disease, but used in 0·5 per cent solution on young plants before its appearance, this disease was considerably lessened. Used as manure, green vitriol completely prevents this disease because it imparts more vigour to the plant. The numerous experiments of Phillipar and Sance in France, of Griffiths in England as well as those of Saccardo, have shown green vitriol to be a preventive. The doses to apply on the large scale do not exceed 2 cwt. per hectare, say 88 lb. per acre; this manure is spread on the soil in the spring the same time as the seed is sown.

Polyporus (polypores).—Prillieux advises to destroy *Polyporus fulvus*, Fries, which lives on fruit trees, and particularly on the olive, the same treatment for anthracnose. After having cut out the fungus, the bark and wood already attacked is removed, then the bared surface is moistened with a 50 per cent solution of green vitriol, rendered more active by the addition of 2 per cent of sulphuric acid. The wounds are afterwards protected against fresh infection by covering them with a layer of tar. Sirodot advises this operation not to be done in autumn, which is that of the fructification of the parasite, and to choose warm dry weather as much as possible.

Exoascus deformans, Fuckel (leaf curl of the peach).—By treating peaches with green vitriol according to Rassiguier's method, and repeating it at intervals, André caused the rust to vanish completely.

Erysiphe communis, Wall. (mildew of the pea).—Deneuville advises green vitriol as a preventive used thus: Sow the peas and cover them in April with a green vitriol in powder, then give the ground a slight but uniform touch with the harrow. Excellent plants which rise up well and free from blight are thus obtained.

Nectria ditissima, Tul. (canker of the pear, the apple, and the beech).—Prillieux recommends, to kill this fungus, and to protect wounds against its invasion, the process just described for the destruction of

polypores and against anthracnose. All the parts of the wood attacked and coloured around the canker must be removed by cutting, for even apparently healthy parts may contain ramifications of the mycelium. By carefully moistening these bared parts with the corrosive solution of green vitriol and sulphuric acid, the cankers are cured.

Dasyscypha Wilkommi, Hartig (canker of the larch).—Prillieux recommends to destroy this fungus which belongs to the *Pezizes* the same treatment as the *Nectria ditissima.*

Claviçeps purpurea, Tul. (ergot of rye).—The spores of this fungus are those which resist immersion for the longest time even in concentrated solution of green vitriol. Solutions of 1-10 per cent have no action on them. In spite of that McAlpine recommends to prevent and combat this disease a 1·4 per cent solution. The spores do not find on the cereals strengthened by this ferruginous treatment the soil favourable to their growth, and the less number of diseased plants is due to the improvement in their power of resistance of both healthy and attacked plants.

Dematophora necatrix, Hartig (white root rot).—Dufour tested comparatively the action of green vitriol and blue vitriol on this fungus, and found the latter much superior to the former. However, Beniling and Behaix recommend green vitriol against rot of vine roots (Wurzelschimmel) where carbon disulphide and sodic fluoride had no action.

Rhizoctinia violacea, Tul. (rhizoctinia of lucerne and beet).—Buback tried to contend against this fungus by spreading 4 kilogrammes (8·8 lb.) of green vitriol on a plot of ground 10 square metres, then sowing beets eight days later after burying the green vitriol. The result was that the iron salt greatly stimulated the growth of the beets, increased the sugar, and that the plot had only 28 per cent of diseased plants against 47 per cent in the check plot.

Gloeosporium ampelophagum (grape rot).—Sulphuring and treating the vine with cupric bouillies have not circumscribed this disease at the same time as the oidium and mildew. Anthracnose must be treated by itself, and only winter treatment with green vitriol has proved entirely satisfactory. Schnorf was the first to advise and use 50 per cent solutions of green vitriol to contend against this disease, and Skawinski was the first to add to these solutions a small amount of sulphuric acid to render the solutions more corrosive. This last formula has given perfect results. Studied in different countries, this mixture has undergone some alterations of no importance. Sorauer advises a 40 per cent solution, Tomé a 35 per cent, Ghirardi from 0·5-2 for young shoots, so as to prevent scorching by stronger doses. Bolley advises 50 per cent of green vitriol and 5 per cent of sulphuric acid; Galloway 6 per cent of green vitriol and 0·45 per cent of sulphuric acid; Scribner 23·6 per cent of green vitriol, 6·6 per cent of blue vitriol, and 1·9 per cent of sulphuric acid; Thomas 20 per cent of green vitriol, 14 per cent of blue vitriol, and 12 per cent of fat lime; finally, Orillard 25 per cent of green vitriol and 10 per cent of blue vitriol.

Contrary to the opinion of Berlèse, who attributes the success of these mixtures to their (free) sulphuric acid content, alone capable in

his opinion of sterilizing the cankers produced by anthracnose, green vitriol employed pure is perfectly capable of giving excellent results; moreover, it has the advantage over 10 per cent sulphuric acid solutions of not scorching the buds, and only retarding their unfolding slightly. If the addition of blue vitriol be not injurious, and if mixtures containing this product have given excellent results in the Haute-Garonne, this salt is not indispensable, and adds to the cost of the treatment. To-day 50 per cent solutions of green vitriol acidulated by sulphuric acid are in constant use in the Bordelais; they are included in the annual treatment of vines in Medoc, and in all districts which suffer from anthracnose. The green vitriol solutions are made thus: 50 kilogrammes (110 lb.) of green vitriol are placed in a wooden or stoneware vat, then mixed with 1 litre of sulphuric acid of 53° B. Whilst stirring with a stick 100 litres (22 gallons) of hot water are run into the receiver. The precaution of first mixing the green vitriol crystals with the sulphuric acid is necessary to avoid projection of corrosive liquid. The solution is applied hot to prevent crystallization on cooling. The stock is coated with a big brush, or with a plug of rags attached to the end of a wooden handle, then all the stock, the stem, the arms, and the runners are soaked without respecting the eyes. However, it is necessary to coat from below upwards so as not to scorch the buds; it is also preferable to unbark the stock before using this corrosive liquid. The operation should always be carried out during the repose of vegetation; it is a winter treatment which is best done twice with fifteen days' interval; the last operation takes place fifteen days before the opening of the leaf, that is to say, at the moment the spores germinate. The best season is therefore the end of February or the beginning of March, but often this treatment is applied at the moment the buds begin to open. After coating the wood should become black. If rain ensue and this change has not taken place the treatment must be repeated. Green vitriol solutions in no way attack the buds, but none the less retard their opening fifteen days. The districts where anthracnose prevails suffer much from frost, and this retardation of vegetation is very beneficial to the vine. The operation should be done in calm weather so as to avoid too great evaporation of the solution. It takes 8-10 litres (1·76-2·2 gallons) of this solution for 1000 stocks of vines. Spraying may be used with great advantage, the work is done quicker than with the brush, but it involves the use of tools with glass reservoirs. When anthracnose is developed during plant growth, it is contended against by mixtures of sulphur and green vitriol in powder; this treatment stops the development of the spores, but it should be renewed several times to protect the vine; it is, in fact, a preventive rather than a curative method.

Ophiobolus graminis, Sacc. (disease of the stem of wheat).—This disease may be avoided by burying in the soil 80 kilogrammes of green vitriol per hectare (70·4 lb. per acre) (McAlpine).

Dothichiza populea.—To prevent infection through wounds it is sufficient to coat them with a solution of 10 per cent of green vitriol and to cover them with a mastic.

Use of Green Vitriol against Insects.—*Anthonomus pomorum.*

(apple blossom weevil).—Mohr advises to kill this insect in winter when it seeks refuge in the inequalities of the bark, to scrape the trunk, collect and burn the bark, and coat the whole trunk afterwards with a pasty mixture of 20 lb. of green vitriol, 10 gallons of water and a sufficiency of potters' clay. Spraying with a 20 per cent solution of green vitriol would appear to be as efficacious as liming the trees or Balbiani's coating.

Cochylis ambignella, Hubn. (tortrix of the vine).—The grubs resist somewhat concentrated solutions of green vitriol. A 2-3 per cent solution has no effect (Mohr), nor a 10 per cent solution (Dufour). Martini diminished the *Cochylis* 27 per cent by winter decortication followed by coating with a 45 per cent solution of green vitriol and 1 per cent of phosphoric acid.

Tipula pratensis, L. (meadow gnat).—The larvæ of the tipula, which cause ravages in meadows and lawns, are killed by green vitriol: it is, however, preferable to till the meadow, spread green vitriol, and sow again.

Aphides.—Naked plant lice are sensitive to the action of green vitriol. A 1 per cent solution kills them (Mohr). On fruit trees injected with green vitriol and conveying this product in their sap, cochineals such as *Diaspis fallax* and *Mytilaspis pomorum*, which live on this sap, gradually disappear. Mohr found that the larvæ of the woolly aphis *Schizoneura lanigera*, Hausmann, are killed by an emulsion of green vitriol 1 lb., amyl alcohol 5 lb., water 10 gallons. The action of green vitriol on phylloxera is *nil*.

Nematodes.—Green vitriol applied in large doses as manure on infested fields kills nematodes (Zimmermann).

Earth-worms (Lombricus) are also destroyed by green vitriol, which can be mixed with the manure.

Snails and Slugs.—Slugs are very sensitive to green vitriol. To destroy them sow a mixture of green vitriol and sand in the evening, preferably in wet weather, on the soil frequented by snails and slugs. Rouzaud advises to protect vine buds from slugs to coat the stem with a solution of green vitriol, which penetrating through the mucous of the slugs kills them if they climb on a stem treated in that way.

69. Ferric Sulphate, $Fe_2(SO_4)_3$.—**Preparation.**—By heating 100 parts of green vitriol, 100 parts of water, and 20 parts of sulphuric acid, then adding nitric acid until no more brown fumes appear. The brown solution on evaporation yields a yellow salt.

Properties.—Soluble in water and endowed with the disinfectant properties of green vitriol.

Use.—Griffiths particularly recommends it against parasitic fungi. As a tonic he regards it as superior to green vitriol because it is more directly assimilable by the roots.

70. Ferrocyanide of Potassium (yellow prussiate).—**Preparation.**—By calcining blood in closed vessels with potassium carbonate potassium cyanide is formed and removed by lixiviating the mass with boiling water. The lye is then boiled with iron in contact with air; there is absorption of oxygen and yellow prussiate is formed. The crystallized salt is obtained by concentration and evaporation.

Use.—Mouillefert tried yellow prussiate on *Phylloxera vastatrix*. He watered a phylloxera-infested vine in a pot containing 3 litres of earth with a 2 per cent solution. At that strength yellow prussiate killed all the phylloxera. Mouillefert renewed his trials on the large scale. He laid down 100 grammes ($3\frac{1}{2}$ oz.) of prussiate around each stock and afterwards applied water. The results confirmed the poisonous action of this substance. Unfortunately, it is not without effect on the plants and it temporarily injures the vine. Knop formerly showed that if yellow prussiate was capable of imparting to the plant the iron which it required, it was, on the other hand, often injurious to it. He made the curious observation that the prussiate added in small dose to no matter what nutritive liquid stopped growth forthwith of the plants in no matter what stage of growth. Without dying the plant appeared to stop growth; it subsisted but showed no growth. It follows from the experiments of Bahadur (?) that yellow prussiate is a very feeble poison to young plants and absolutely harmless to fungi when used in the dark. It is quite otherwise in the light. It decomposes with formation of prussic acid which renders it poisonous.

71. Prussian Blue (ferric ferrocyanide).—Discovered at Berlin, 1710.—**Preparation.**—By acting on yellow prussiate with a ferric salt.

Properties.—Prussian blue is a precipitate insoluble in water but soluble in oxalic acid. Weak acids do not decompose it, but strong acids and caustic alkalies destroy it.

Use.—Prussian blue in paste was used in 1894 by Galloway and Fairchild. The former tried it against rust of cereals, the second to prevent *Entomosporium maculatum*, Lev. (spots of the leaves of the pear-tree). Although the adherence of this paste was superior to that of bouille bordelaise, Galloway found that Prussian blue possessed no anticryptogamic property owing to its absolute insolubility in atmospheric agents. In spite of a large number of sprayings the fields of oats and summer wheat were invaded by rust. Fairchild, however, remarked a certain action on the pear-trees treated, although much weaker than modified *eau celeste*.

72. Borate of Iron, FeB_4O_7.—**Preparation.**—By adding borax to a ferrous salt. A grey precipitate is formed which turns yellow rapidly by oxidation. Fairchild prepares a borate of iron paste by dissolving 6 lb. of dry green vitriol in 50 gallons of water and adding a solution of 24 lb. of borax in 50 gallons of water. Fairchild tried this paste against *Entomosporum maculatum* (spots of the leaf of the pear) and against *Phyllosticta sphæropsidea*, E. and E. (spots of the leaf of the chestnut). This paste behaved like all pastes containing insoluble iron, that is to say, without action on the spores of fungi they are somewhat injurious to vegetation. Galloway's experiments to combat rust of oats and summer wheat with this bouillie also gave negative results.

CHAPTER XI.

POTASSIUM BICHROMATE (BICHROME)—CHROME ALUM—POTASSIUM PERMANGANATE—MANGANESE SULPHATE—NICKEL SULPHATE—COBALT SULPHATE.

73. **Potassium Bichromate,** $K_2Cr_2O_7$; 74. **Chrome Alum,** $K_2SO_4Cr_2(SO_4)_3 24H_2O$.—**Preparation.**—Bichromate of potash is obtained commercially by calcining chrome ore on the sole of a reverberatory furnace with half its weight of nitrate of potash. The mass is then lixiviated with water and acetic acid added to saturation. Whilst precipitating silica and alumina this acid converts the neutral chromate into bichromate. After filtration the liquor yields, when concentrated, orange crystals of bichromate of potash. Chrome alum is obtained by treating a solution of 150 lb. of "bichrome" with 250 lb. of sulphuric acid and 60 lb. of alcohol.

Properties.—Crystals of "bichrome" are permanent in the air. They dissolve in ten times their weight of water at 29° C. Chromates are very poisonous; in small doses they produce by a specific slow poisoning caries of the bones of the nose.

Action of Chrome Salts on Plants.—Chrome salts, chiefly chromates, are poisonous to plants. H. Coupin in 1898 determined the toxicity of the different chrome salts by adding them to a nutritive solution; he found that the following quantities disturbed the growth of cereals :—

TABLE XXIV.—*Showing the Toxic Dose of Different Chrome Salts in a Nutritive Solution* (Coupin).

	Per Cent.
Chrome alum	1·142
Chromium sulphate	0·5
Chromic acid	0·00595
Potassium chromate	0·0625
Bichromate of potash	0·03125
Sodium chromate	0·0125
Bichromate of soda	0·0064
Ammonium chromate	0·0625
Bichromate of ammonium	0·025

Action of Chromium Salts on Parasitic Fungi.—It follows from Hitchcock and Carleton's experiments that whilst a 1 per cent solution of chrome alum has no action on the uredospores of the *Puccinia coronata*, Corda, a 1 per cent solution of bichromate of potash lowers considerably the germinating capacity of these spores after twenty-four hours' immersion and destroys them by more prolonged contact. A 0·1 per cent solution has no action on the uredospores, but if the

contact be prolonged after nineteen hours the germination of the spores becomes more difficult.

Use.—*Rust.*—As a preventive against rust, Galloway tried bichromate of potash. The seeds were immersed for twenty-four hours in a 5 per cent solution of bichrome and the ground sown watered with a solution of the same strength. The use of the bichrome enabled him to free the field from rust, but the yield was inferior to that on the check plot infested with rust. Bichrome solutions act in as poisonous a manner on the seeds as on the spores which contaminate them, and it follows after this disinfection that the seeds do not spring up except in small proportion. The watering of the sown ground is likewise very prejudicial to the sprouting of the grain.

Stinking Smut (bunt).—Kellermann and Swingle came to the same conclusions as Galloway as to the action of bichrome on the spores of fungi and on the grain of cereals. Although an immersion cf twenty hours in a 5 per cent bichrome solution kills the spores of *Tilletia caries*, Tul., the treatment cannot be utilized as the grains suffer too much.

Peronospora viticola, De By. (mildew of the vine).—Kaserer tried as a substitute for bouillie bordelaise: (1) a mixture of 1 per cent of bichromate and lime, (2) a mixture of 1 per cent of chrome alum and lime; these two bouillies only gave absolutely negative results, but whilst the bichromate of lime greatly damaged the leaves the hydrated oxide of chromium did not injure them.

Conchylis ambignella, Hub. (cochylis).—Dufour tried against the caterpillar of this butterfly a 3 per cent solution of bichrome, but he found that it in no way disturbed the caterpillars, whilst it spoiled the grapes.

75. Permanganate of Potash, $KMnO_4$.—**Preparation.**—By heating in an iron crucible a mixture of 50 parts of manganese dioxide with 50 parts of potassium chlorate and 60 parts of potash dissolved in the smallest quantity of water. This mixture is gradually heated to dull redness, then cooled and extracted with boiling water. A purple liquid is thus obtained which crystallizes on evaporation in blackish violet needles with metallic lustre.

Properties.—Potassium permanganate dissolves in 15-16 parts of cold water. It is a powerful oxidizing agent decomposing organic matter in the cold. Owing to this property it acts as an energetic and rapid disinfectant (Condy's fluid); its action is instantaneous, especially in the presence of an acid. Weak permanganate solutions do not keep in open vessels, and it is best to use these anticryptogamic solutions immediately after their preparation.

Action on Fungi.—The spores of fungi resist the action of this oxidizing agent better than that of poisonous salts. Hitchcock and Carleton found that the uredospores of the *Puccinia graminis*, Pers. (linear rust) can germinate in a 1 per cent solution of permanganate of potash. Arieti found that the dose required for the disinfection of seed-corn was so strong that it killed the grain as well as the adherent spores. It is otherwise with the mycelium of fungi. The tender filaments of the mycelium are easily destroyed by permanganate solu-

tions; the effect is produced instantaneously. But as permanganate solutions cannot penetrate into the organs of plants to destroy the mycelium which vegetates in and between the cells, permanganate finds no application except to destroy fungi, the mycelium of which live on the surface of the plant, that is to say *Erysiphe* and *Capnodium.*

Action on Insects.—The action of permanganate is weak and sometimes *nil.* Perroncito immersed the eggs of *Bombyx Mori,* L. (silk-worm) in a 1 per cent solution. After twelve hours the action was *nil;* only after twenty-four hours' immersion were the greater part of the eggs destroyed. Trials made in 1872 (Samal process) to destroy the phylloxera of the vine by watering the stocks with a 0·06 per cent solution failed because the permanganate was decomposed before reaching the roots infested with this aphis. However, Stengele recommends a 1·25 per cent solution of permanganate to kill infallibly the woolly aphis.

Use.—*Erysiphe communis,* Wal. (mildew of the pea).—Douaire simultaneously tried sulphur and permanganate of potash against this parasitic fungi, the mycelium of which lives on the surface of the diseased plant, and he obtained the best result with the latter. Used at the rate of 1 lb. in 100 gallons of water permanganate completely stopped the invasion of this fungus. A few days after this treatment the less-attacked leaves had become green again, whilst those which were greatly attacked bore black spots in the places where the epidermic cells had suffered from the fungus. To obtain a definite result spraying must be done carefully so that both surfaces of the leaves are moistened. This treatment only produces a curative effect, never a preventive one. It can in no way prevent a fresh invasion by spores coming from elsewhere.

Oidium Tuckeri, Berk. (oidium of the vine).—Of all the fungi the mycelium of which live on the exterior of the diseased plant the most formidable is the oidium of the vine, which, if very resistant to copper salts, may be easily contended against by sulphur and soluble sulphides. Permanganate of potash has also been recommended to kill this parasite. Guocdenovic tried a 0·1 per cent solution of permanganate which proved entirely satisfactory. Kulisch repeated these experiments to compare the results with sulphur. He used solutions made at the rate of $1\frac{1}{4}$-$2\frac{1}{2}$ lb. per 100 gallons of water. He found permanganate produced good results, but the good effect was purely local, and to obtain a complete result it was necessary to reach the whole surface of the plant by spraying. On the other hand, sulphur, which acts by the vapours which it disengages and which penetrate everywhere, produces complete disinfection without it being necessary to cover the whole surface of the vine with sulphur. It has been seen that it is sufficient when the temperature and the atmospheric conditions are favourable to deposit the sulphur at the foot of the stocks to destroy the oidium completely. The advantage of permanganate of potash lies in the fact that it can be mixed with cupric bouillies without losing its properties. Added to bouillie bordelaise one can contend in a single treatment against oidium, mildew, and black rot, which is a great economy of time.

Peronospora viticola, De By. (mildew of the vine).—Ch. Truchot recommends a permanganate solution of 0·125 per cent against mildew. Tried in the Canton of Vaud in Switzerland it sometimes gave excellent, sometimes negative results. It is otherwise with a mixture of bouillie bordelaise and permanganate of potash. Guocdenovic made up bouillies containing 0·75 per cent, 0·5 per cent, 0·25 per cent of blue vitriol and 0·1 per cent of permanganate of potash. Compared against ordinary bouillie bordelaise these permanganate bouillies gave better results even when they only contained 0·25 per cent of blue vitriol and 0·1 per cent of permanganate of potash. This mixture whilst giving excellent results effects great saving in copper. The permanganated bouillie bordelaise behaves both like bouillie bordelaise and as blue vitriol, that is to say, it possesses, along with the reserve of copper to prevent the invasion of the mildew and prolong the action of the bouillie remaining on the leaves, a very active substance having an immediate deadly action on the exterior organs of these fungi, the conidiophores. This bouillie gives good results when it is a case of arresting a sudden invasion during a moist warm period of summer. However, permanganate alone does not suffice to contend against this disease, for it has only a curative action and is entirely deprived of preservative effect. It is therefore necessary to multiply the treatments an infinite number of times with permanganate alone to get a result analogous to that obtained with cupric bouillies or permanganated cupric bouillies.

Disinfection of Trees.—It has been recommended to coat fruit trees in the spring when the buds are barely formed with an 0·125 per cent solution; it is even recommended to spray the whole trees with this solution after flowering. The results were very satisfactory.

Botrytis Douglasii, V. Tub. (conifer disease).—The rot of conifers produced by *Botrytis cinerea*, Pers., has been combated by Van Biervliet by making sprayings with a bouillie consisting of—

Copper sulphate	700 oz.
Carbonate of copper	1360 ,,
Permanganate of potash	85 ,,
Soft soap	225 ,,
Rain water	500 gallons.

Nematoides. — Humphrey got excellent laboratory results against the nematoides of the violet by frequently spraying with a 0·05 per cent solution. The experiments on the large scale, however, did not succeed.

76. Manganese Sulphate, $MnSO_4 5H_2O$.—**Preparation.**—By dissolving manganese in sulphuric acid.

Properties.—The same as green vitriol.

Action of Manganese Salts on Plants.—The action of manganese salts on plants has been examined chiefly in Japan. The experiments of Loew and Honda to determine the action of sulphate of manganese on the growth of *Cryptomeria japonica* have shown that manganese salts possess like copper and other analogous salts the property of stimulating the growth of the plant and in that way increasing the yield of the crop. The yield in their case was 646·7 grammes against 316·9

grammes for the check plants. Aso found manganese chloride, used as a manure in the cultivation of rice, increased the yield 42 per cent. Nagao pointed out this property for sulphate of manganese, and finally M. Fukutome observed that a mixture with manganese sulphate had a superior action on plants to that of these salts used separately. Although manganese does not form according to Gossel's researches a plant food, in general the manganese content of cultivated plants is barely appreciable, yet trees, especially pines, contain appreciable quantities; it hastens vegetation and stimulates growth.

Use.—*Peronospora viticola,* De By. (mildew of the vine).—Sbrozzi used this salt to combat the mildew of the vine, but the results were negative. Kaserer did not succeed better with 0·5 per cent solutions of borate of manganese.

77. Nickel Sulphate, $NiSO_47H_2O$.—**Preparation.**—Nickel sulphate is formed by dissolving nickel, its hydrated oxide or its carbonate, in dilute sulphuric acid of 15° B. It crystallizes from its solutions in the hydrated state with 7 molecules of water.

Properties.—Crystallized nickel sulphate is green; it dissolves readily in water. Alkalies yield with solutions of nickel sulphate an apple-green precipitate of hydrated oxide of nickel insoluble in water, soluble in ammonia and in carbonate of ammonia. The ammoniacal solution of protoxide of nickel dissolves silk (Schlossberger). There is thus great analogy between the physical and chemical properties of nickel and copper sulphates as between nickel hydrate and copper hydrate. A nickel hydrate bouillie behaves as to solubility in atmospheric agents and its adherence like bouillie bordelaise.

Action of Nickel Sulphate on Plants.—Nickel sulphate, like copper sulphate and other poisonous plants, possesses the property of stimulating the vitality of these plants if absorbed by them in minimum proportion. Richards treated different fungi and algæ growing in nutritive solutions with small quantities of nickel, copper, zinc, and cobalt sulphates, sodium fluoride, lithium nitrate, sodium arseniate. The dose required to stimulate algæ is much less than for fungi. By increasing the dose there is an immediate poisonous action on plants; $2\frac{1}{2}$ milligrammes of nickelous oxide used as nickel sulphate in 1 litre of water ($2\frac{1}{2}$ parts in 1,000,000) stop the growth of maize and haricot (Haselhoff). Nickel sulphate behaves like blue vitriol in a nutritive solution used to combat the cryptogamic diseases of plants; it, owing to the infinitesimal quantities absorbed by plants, imparts more vigour, and that in itself gives more resistance to the plant. However, the stimulating effect of nickel sulphate is not so decided as that of copper salts (Aso, Nakamura, and Suzuki).

Action of Nickel Sulphate on Parasitic Fungi.—Nickel sulphate has a very toxic action on parasitic fungi. It much resembles that of blue vitriol, to which it is superior or inferior according to the parasite treated. A 1 per cent solution of nickel sulphate does not kill the uredospores of *Puccinia coronata,* Cord.

Use.—*Peronospora viticola,* De By. (mildew of the vine).—Galloway tried, in 1889, nickel sulphate and nickel hydrate against blue vitriol and cupric bouillie. He concluded that its sporacidic and pre-

servative action is inferior to that of cupric derivatives. Sbrozzi's trials in 1900 confirmed this conclusion. Guocdenovic in 1900 made comparative experiments with 0·25, 0·5, 0·75 per cent copper bouillies and with nickel hydrate bouillies, made like bouillie bordelaise with 0·25, 0·5, and 1 per cent of nickel sulphate. The action of these bouillies was identical. The 0·25 per cent nickel hydrate bouillie was still active, and more effective than the bouillie bordelaise with 0·25 per cent of blue vitriol. He concluded that nickel bouillie could perfectly well replace bouillie bordelaise against this fungi.

Botrytis cinerea, Pers. (grey rot of the vine).—Viala and Gouirand made interesting researches on the comparative action of nickel and copper sulphates on this redoubtable fungus. According to the experiments copper salts have little action on the germination of the *Botrytis*. Whilst the spores of *Peronospora viticola* are killed in a solution of 3 parts in 10,000,000 of blue vitriol, it takes a 5 per cent dose of blue vitriol to prevent the germination of *Botrytis cinerea*. It is not so with nickel sulphate which is 40 times stronger than blue vitriol. In a solution of 2 parts per 10,000 the spores are almost entirely prevented from germinating. Nickel carbonate has shown the same superiority as compared against the Burgundy bouillie, for whilst it takes a 7·5 per cent cupric bouillie to prevent all spores from germinating in sixteen hours, a 1 per cent nickel bouillie has the same effect. The results, repeatedly verified, have always been the same. Experiments on the large scale against grey rot do not appear to have been made as a sequel to the laboratory experiments of Viala and Gouirand. Is it because aluminium sulphate, much cheaper, produces equally good results?

78. Cobalt Sulphate, $CoSO_4 7H_2O$.—It was purely of scientific interest to investigate the action of cobalt salts on plants and parasitic fungi, for these salts are too dear to be used on the large scale. Cobalt sulphate was tried comparatively against nickel sulphate and blue vitriol by Richards. Its action on plants was found to be analogous to that of the two latter salts, stimulating in small dose, poisonous in larger doses. The experiments of Aso, Nakamura, and Suzuki, on *Allium*, *Brassica chinensis*, *Hordeum*, and *Pisum*, enable us to conclude that its stimulating action is not very decided.

CHAPTER XII.

RED LEAD—LEAD ARSENIATE—LEAD ARSENITE—LEAD CARBONATE (WHITE LEAD)—LEAD ACETATE (SUGAR OF LEAD)—SILVER NITRATE (LUNAR CAUSTIC)—SILVER CHLORIDE.

79. **Red Lead,** Pb_3O_4.—**Preparation.**—By heating massicot PbO in special furnaces to 450°-500° C.

Properties.—Red lead is a brilliant red powder, insoluble in water.

Use.—Seed beds may be completely preserved against the attacks of sparrows and other granivorous birds as follows: 20 lb. of seed are mixed with 1 lb. of red lead and stirred, so that the seeds may be uniformly red. The seed is sown as usual and the birds shun the land where they have been sown. Von Tubeuf recommends red lead particularly to preserve pine and spruce fir seeds.

80. **Arseniate of Lead,** $Pb_3As_2O_8$.—**Preparation.**—By acting on a solution of 10 lb. of arseniate of soda with 18 lb. of lead acetate, or 15 lb. of lead nitrate, dissolved in water. To prepare the bouillie the liquor is made up with water to 250-376 gallons. Marlatt's bouillie contains 10-24 lb. of arseniate of lead and 50 lb. of glycose in 1000 gallons of water.

Properties.—Lead arseniate is one of the most insoluble of arseniates in water. It forms in the bouillie a finely divided precipitate which remains well in suspension, which is not the case with many of the arsenite greens of a density of 3 and the consistency of which is very granular.

Action on Plants.—Owing to its insolubility it is perfectly harmless to the plant, and that is one of the great advantages of this product, for all arseniates are more or less soluble in water, and thus more or less injurious to plants. Woods' experiments on potatoes have shown the harmlessness of three sprayings annually and spreading 5·5 lb. of arseniate of lead altogether (? per hectare, say 4·4 lb. per acre). Besides, it was impossible to find even traces of arsenic in the tubers. A bouillie containing 0·5-1·0 per cent of arseniate of lead never scorches the leaves, so that bouillies containing a large proportion of poison may be used, when the insects stand strong doses of arsenic and resist all arsenite of copper bouillies.

Action on Insects.—Its poisonous action on insects is not in equal doses as rapid as that of copper arsenite. Arseniate of lead is a violent poison for man. Used without precaution it is as dangerous as lead salts and arsenites. It chiefly affects the sight. Some cases have been quoted in America where this bouillie is in constant use.

Use.—Lead-arseniate bouillies cannot replace copper-arsenite and

lime-arsenite bouillies in every case. Its greater adherence, increased by the addition of glucose, is such that it remains fixed on the organs of the sprayed plants during the whole season. This adherence, therefore, excludes it in all cases where the plants or the fruits treated are intended for food. But, wherever that is not the case, lead arsenite may replace copper arsenite. The bouillies are best made on the spot; 0·2 per cent suffices in most cases. But some parasites require 0·7 per cent, and even 1 per cent. It is calculated that it takes three to four times more of this bouillie to obtain the same result as from that with an emerald-green basis. But the lead-arseniate bouillie, consisting of a flaky precipitate, enables the poison to be more uniformly distributed, and by its white colour shows the spots touched. A preparation of arseniate of lead on the market called "Disparin," contains lead oxide 49, arsenic acid 16, tar 4, water 31 = 100. Lead arseniate is especially used against a butterfly whose caterpillar has become quite a plague—

Ocneria dispar, Sch., or *Liparis dispar*, L. (*Bombyx dispar*, gypsy moth).—Spraying with cupro-arsenical bouillies is without effect as the caterpillars are capable of absorbing strong doses of copper arsenite without dying. By the use of a 1 per cent lead-arseniate bouillie very satisfactory results have been got in America. To destroy the caterpillars the spraying must be done at the time they are hatched, for the young caterpillars are more sensitive than the adults. It is possible to destroy 90 per cent of the young caterpillars and only 60-70 per cent of the adults. This process, therefore, appears to give better results than the gathering of the nests of eggs in winter.

Leptinotarsa decemlineata (Colorado beetle).—Woods recommends to destroy insects injurious to potatoes, such as the Colorado bettle, altises, etc., a bouillie consisting of 0·24 per cent of lead arseniate. If it be desired to combat cryptogamic parasites simultaneously there is added to bouillie bordelaise 24 lb. of arseniate of lead per 1000 gallons. Lead-arseniate bouillie is in general use in America. The following is, however, a list of the insects against which it has been particularly recommended: (1) *Galeruca luteola*, Sch., on the elm; (2) *Galeruca anthomelæna*, Schr., on the elm; (3) *Crioceris asparagi*, L., asparagus beetle; (4) *Rhopobota Vacciniana*, Pack., butterfly injurious to the cowberry (whortleberry, Kirkland); (5) *Orthocraspeda trima*, Moore, butterfly injurious to the cacao tree (Zehntner); (6) *Plutella, Margantia, Mamestra*, aphides, insects injurious to cabbages (Garman); (7) *Ennomos subsignaria*, phalena of the apple (Garman); (8) *Carpocapsa Pomonella*, codlin moth. Trials to destroy this codlin moth were made with a bouillie bordelaise containing 6-12 lb. of lead arseniate or of disparin per 1000 gallons. Gillete and Garman by its use reduced the percentage of wormy apples from 50 per cent (on the check trees) to 4 per cent. (9) *Emphroctis chrysorrhea.*—Weed advises to cut the nests in the spring and spray with lead arseniate on the young caterpillars; (10) *Grapholitha botrana* (tinea of the vine).—Slingerland recommends three sprayings with a 1 per cent bouillie of lead arseniate, the first a little before flowering, the second after flowering, and the third when the grapes are the size of a pea.

81. Lead Arsenite, $PbAs_2O_6$.—**Preparation.**—Sodium arsenite 6 oz., lead acetate 32 oz.; dissolve separately in water, mix with solutions, and make up the bulk to $62\frac{1}{2}$ gallons. It may be bought under the name of *arsenoid rouge* (red arsenoid).

Properties.—Precipitated arsenite of lead is finer than arseniate of lead, but it is a little more soluble in water than the latter. Lead arseniate is therefore preferred against plant diseases.

82. Lead Carbonate.—Passerini tried lead carbonate against *Peronospora viticola*, De By., but he obtained no useful result.

83. Lead Acetate, $Pb(C_2H_3O_2)^2$, $_3H_2O$.—**Preparation.**—By dissolving lead in acetic acid.

Properties.—Soluble in water, with a saccharine taste. Very poisonous, like all lead salts, and absorbed in small regular doses it causes the complaint known as painter's colic.

Action of Lead Salts on Plants.—Lead acetate acts on plants as on our organism. Placed in strong doses in contact with the roots of plants it kills them, yet young plants of peas, maize, and oats, cultivated in nutritive solutions, are not killed in four days after receiving 1 per cent of lead as lead nitrate (Nobbe, Bassler, Will). By slow absorption in small doses it eventually produces a paralysis of growth, an arrest of the normal growth, and a special *nanisme* (?).

Action of Lead Acetate on Parasitic Fungi.—Hitchcock and Carleton found that the germinative power of the uredospores of *Puccinia coronata*, Corda, was reduced by immersion in a 1 per cent solution of lead acetate.

Use.—*Tilletia caries*, Tul. (bunt).—A commercial product with an acetate of lead basis, sold as "Germinateur guarante," was recommended for the disinfection of seed-corn. Schribaux, the director of seed control of the Agronomical Institute of Paris, examined this product comparatively with blue vitriol, and found it 100 times less active than the latter on the spores of *Tilletia caries*, Tul. Lead acetate cannot therefore replace blue vitriol in the disinfection of seed-corn.

Peronospora viticola, De By. (mildew of the vine).—Kaserer made a series of experiments against this disease, spraying with the following bouillies:—

Mixture of	100	grammes	of lead acetate	and milk of lime.
,,	250	,,	,, ,,	,,
,,	500	,,	,, ,,	,,
,,	500	,,	of lead nitrate	,,

The lead hydrate which is formed by lead acetate or nitrate with milk of lime appears to have, owing to its solubility in pure water, a rather decided action on the spores of *Peronospora viticola*. Owing to the rapid conversion of lead hydrate into insoluble carbonate of lead, the action of the bouillie is not so lasting as that of copper bouillies. Besides the adherence of the deposit is less than that of bouillie bordelaise. The vines treated showed no signs of poisoning.

84. Nitrate of Silver.—**Preparation.**—By treating pure silver with nitric acid the liquor forms colourless lamellæ of silver nitrate on cooling.

Properties.—Silver nitrate is soluble in half its weight of water and in the tenth of its weight of boiling water; it dissolves also in 10 parts of cold alcohol and 4 parts of boiling alcohol. Fused and run into sticks silver nitrate yields the infernal stone used in medicine. Silver nitrate decomposes readily; it is slowly reduced by light and organic matter to silver oxide. In medicine it is used to cauterize wounds and remove false membranes (proud flesh); internally it is used in doses of 1-4 centigrammes; in greater doses it is poisonous. It is an antiphlogistic and sedative. Silver nitrate combines with albumen, forthwith forming a precipitate of an albumen salt soluble in excess of albumen and in solutions of common salt. Nitrate of silver, therefore, behaves towards albumen like many powerful antiseptics. Its powerful action on spores and microbes results from these properties and its action on the living plasma. In very dilute solution it interferes with the vitality of the plasma which on contact therewith blackens owing to the metallic silver formed.

Action on Plants.—It suffices to water plants with a very dilute solution of nitrate of silver to kill them infallibly. To prevent wheat from germinating it suffices to steep it in a bath containing 0·029 gramme of nitrate of silver per litre, that is, 29 lb. in 10,000 gallons.

Action on Fungi.—Nitrate of silver is as injurious to fungi as to plants. It only requires an infinitesimal dose of this substance, which analysis cannot detect, to prevent the spores of the saprophytic fungus, *Aspergillus niger*, from germinating (Raulin).

Use.—Silver nitrate is not used as an anticryptogamic in the struggle against the diseases of plants, its action on the latter being too deadly. A process recommended in 1872 by Petit for the destruction of the phylloxera gave no result.

85. Silver Chloride, $AgCl$.—**Preparation.**—By precipitating a solution of silver nitrate by a solution of common salt, a white curdy precipitate forms, soluble in ammonia and hyposulphite of soda.

Properties.—Silver chloride is insoluble in water. Its properties are the same as those of the nitrate, that is to say, it decomposes readily in light and in presence of organic substances.

Use.—*Peronospora viticola*, De By. (mildew of the vine).—Pauli advised a mixture of silver chloride and hyposulphite of soda tinted with eosin, and sold as "Puknos," against the cryptogamic diseases of the vine, tomatoes, potatoes, rose-trees, and fruit-trees. The good anticryptogamic effects produced in general have been observed in a large number of vineyards treated. Unfortunately the use of this solution was followed, especially after great heat, by serious burning of the leaves. Its two components being too toxic for plants the use of "Puknos" was abandoned.

CHAPTER XIII.

COPPER SULPHIDE—COPPER NITRATE—COPPER CHLORIDE—COPPER SULPHITE—COPPER SULPHATE (BLUE VITRIOL).

86. Copper Sulphide, CuS.—**Preparation.**—(1) By passing a current of sulphuretted hydrogen into a solution of a copper salt. The black precipitate formed is filtered and washed with a solution of sulphuretted hydrogen. (2) By double decomposition of sulphate of copper by the sulphide of an alkali or alkaline earth.

Properties.—Copper sulphide is an amorphous black precipitate, absolutely insoluble in water. In moist air it oxidizes and forms sulphite and sulphate of copper. By heat it decomposes into basic copper sulphide and sulphur.

Use.—Copper sulphide has been recommended against oidium as well as mildew, that is to say, to unite in a simple treatment both sulphur and bouillie bordelaise. Copper sulphide, containing the necessary elements to fight these two parasites, it was thought might produce the desired effect. It was not so, however, and Viala's experiments at the Montpelier school showed that copper sulphide neither protects vines from mildew nor kills the oidium. Numerous observers hold the same opinion as Viala and condemn mixtures which form copper sulphide. In fact, the copper is so insoluble in this sulphide derivative that this preparation no longer cedes to dew or rain the indispensable amount of copper to prevent the germination of the spores which have been transported by the wind, and the sulphur in the sulphide no longer possesses the properties of sulphur. It is not volatile, and cannot consequently act by its vapours. However, copper sulphide may oxidize in the air and thus cede to the water on the leaves a little soluble copper as copper sulphate. This, in fact, occurs in moist countries, and it is one of the reasons why certain experimenters found a protection in it against mildew equal to that of bouillies. The special bouillies recommended by Fairchild, and afterwards by Rabatè, may perfectly combat oidium, but they have only an imperfect action against mildew. Consisting of a mixture of 4 lb. of copper sulphate and of 4 lb. of sodium polysulphide (liver of sulphur) in 100 gallons of water, in the first instance, and a mixture of copper sulphate and lime sulphide in the second, they contain, along with precipitated copper sulphide, sulphides, or polysulphides of sodium or calcium, as well as precipitated sulphur, which have a well-determined action on oidium.

Against *Entomosporium maculatum* (spots of the leaves of the pear) Fairchild did not find his bouillie superior to ordinary copper bouillies.

Galloway, however, found it act better against rust of oats and summer wheat. Plots treated on 6, 16, and 20 June, then on 5 July, were not diseased, and yielded 10½ units of sound grain against 8½ units in the untreated plots, the plants of which were diseased.

If sulphur be mixed with fat lime in the proportion of fat lime 260 lb., precipitated sulphur 260 lb., water 7 gallons, and the product mixed with a copper salt in the following proportion, above mixture 4 lb., copper sulphate 2 lb., water 10 gallons (Guillon's formula), a bouillie is obtained which, used immediately after its preparation, enables oidium and peronospora to be contended against simultaneously, because sulphur only acts very slowly on copper hydrate to form copper sulphide. It is otherwise if a solution of copper sulphate is mixed with soluble sulphides, or even if the sulphur is added to alkaline bouillie; these bouillies are blackened instantly by the copper sulphide formed and are now merely copper sulphide bouillies, less adherent and less active than bouillie bordelaise.

87. Copper Nitrate, $Cu(NO_3)_2 3H_2O$.—**Preparation.**—By dissolving copper in dilute nitric acid and crystallizing the solution.

Properties.—Soluble in water with the same anticryptogamic properties as copper sulphate.

Use.—Hitchcock and Carleton tried the effect of a 1 per cent solution on the spores of different fungi. At that strength the spores of rust (*Puccinia coronata*) were destroyed. Copper nitrate is regarded as one of the best means of destroying weeds, and is used on the large scale to destroy charlock.

88. Copper Chloride, $CuCl_2 2H_2O$.—**Preparation.**—By dissolving copper oxide in hydrochloric acid, or copper in aqua regia, and evaporating the solutions. Copper chloride bouillies are prepared by mixing 249 lb. of copper sulphate and 219 lb. of calcium chloride; sulphate of lime is precipitated and copper chloride goes into solution.

Properties.—Copper chloride is soluble in water. It behaves like copper sulphate as regards its corrosive action on leaves and its anticryptogamic effects. Its molecular weight being 170, that of copper sulphate 249, and the action of copper salts being in inverse ratio to their molecular weight, the chloride will, in doses of equal weight, be more active, and should be used in smaller doses than copper sulphate. Galloway has, however, remarked that dilute solutions of copper chloride do not attack the leaves of plants like those of copper sulphate; it is necessary to attribute this difference to the different nature of the hydrochloric acid and sulphuric acid which form these two salts, the first is volatile, the second is not so.

Galloway used against the black rot of the vine a mixture, consisting of 7½ oz. of copper sulphate, 4 oz. of calcium chloride, in 62½ gallons of water. This bouillie much diminished the black rot. The vines sprayed six times showed 98·1 per cent of healthy grapes against 41·61 on the untreated stocks. On the other hand, being very dilute it does not attack the leaves at all. A 1 per cent solution prevents the germination of the uredospores of *Puccinia coronata*, Corda (rust of oats), (Hitchcock and Carleton). Along with pure solutions of copper chloride there are used in America, with little success it is true,

solutions containing oxychloride of copper obtained by precipitating copper sulphate with bleaching powder. These bouillies, studied by Fairchild, consist of blue vitriol 2 lb., chloride of lime 3 lb., in 100 gallons of water, or of blue vitrol 2 lb., chloride of lime 4 lb., in 100 gallons of water. These bouillies, which like true Brunswick green, $CuCl_2 3CuO, 4H_2O$, contain a greater or less excess of chloride of lime, produce very disastrous effects on the leaves. Compared with other bouillies they are less adherent and less active against cryptogamic diseases. Tried against *Entomosporium maculatum*, Lev. (spots of the leaves of the pear) they do not prevent the disease, and seriously damage the leaves.

89. **Copper Sulphite**, $CuSO_3$.—**Preparation of the Bouillie**.—Dissolve separately 2 lb. of blue vitriol and 2 lb. of sulphite of soda in 5 gallons of water; mix the two solutions and add thereto a solution of 1 lb. of bicarbonate of soda, make up with water to 20 gallons.

Properties.—Copper sulphite is a green precipitate sufficiently soluble in water to act very energetically on the spores of all cryptogamic fungi. Unfortunately it possesses the fault of all salts of sulphurous acid, that of burning the organs of the plant attacked.

Use.—Copper sulphite bouillie has been recommended against oidium and peronospora. For this purpose about five sprayings a year are required, the first of which is with a 1·0 per cent bouillie, and the succeeding with a 1·5 per cent bouillie. Neither sulphurous acid salts nor free sulphurous acid being capable of replacing sulphur in the struggle against oidium, it is doubtful if copper sulphite possesses the properties required to combat these two parasites of the vine simultaneously. Moreover, its use has not spread, owing to its corrosive action on the leaves, an action which counterbalances its remarkable anticryptogamic properties.

90. **Sulphate of Copper**, $CuSO_4 5H_2O$ (blue vitriol, blue copperas).—**Preparation**.—By roasting mineral sulphides of copper in reverberatory furnaces and in a highly oxidizing current of air. The mass obtained is lixiviated with hot water and the blue liquor crystallized.

Properties.—Blue vitriol prepared thus is often impure.[1] It is thus less active as an anticryptogamic. That used to combat plant diseases is prepared by oxidizing copper turnings in a reverberatory furnace and dissolving the product formed in sulphuric acid. Crystals of copper sulphate are dark blue, transparent, with a styptic taste. They effloresce slightly in the air because above 15° C. they lose a part of, and at 100° C. the whole of their water of crystallization. One hundred lb. of water dissolve 36 lb. (10 gallons) of blue vitriol at 19° C., 88 lb. at 50° C., and 213 lb. at 104° C. In medicine its emetic properties are utilized in doses of 25-30 centigrammes. In croup it is administered even to

[1] It in fact often contains green vitriol and zinc sulphate. If it be desired to detect these the blue vitriol is dissolved in water, and carbonate of soda or milk of lime added. Pure blue vitriol gives a sky-blue precipitate, if it contains green vitriol it gives a dirty-blue precipitate, if it contains zinc sulphate the precipitate is of a pale bluish colour. [Peroxidize the solution with nitric acid, add large excess of ammonia or potash (KHO), filter, a brown residue = iron. The agricultural quality of blue vitriol contains up to 50 per cent or more of green vitriol.—Tr.]

children in doses of 1-2 centigrammes every ten minutes until the false membranes are expelled. Blue vitriol is, moreover, a powerful disinfectant, used especially to disinfect linen soiled in cholera cases, typhus, and other epidemic diseases. Blue vitriol is not poisonous to man to the same extent as lead, mercury, arsenic, antimony, and phosphorus. It acts as a caustic on the mucous membranes, and may produce, when it is absorbed in abundance by the stomach, a gastro-intestinal catarrh, which is rarely fatal. Given in certain regular doses it may interfere with the functions of the nervous and muscular systems and produce cachexy, but that disappears rapidly with the cause.

Blue vitriol coagulates albumen ; it is thus hæmostatic like ferric salts, but copper albuminates are soluble in alkalis, acids, alkaline chlorides, and even in an excess of albumen. This property explains the comparative harmlessness of copper salts which are regularly eliminated by the kidneys. Absorbed by the stomach only a small portion of it enters the blood. The stomach eventually tolerates very strong doses. At the Salpetriere up to 125 grammes of ammoniacal sulphate of copper were given to epileptic patients in 165 days. Blue vitriol in doses of 25-60 grammes (383-920 grains) is generally fatal, but cures are known after absorption of 125 grammes (1918 grains). Such large doses are, moreover, difficult to swallow, the stomach soon rejecting poisonous doses. Copper salts are more poisonous the greater their solubility ; the oxides, as well as metallic copper, have in fact little action on our organism. Contrary to an ancient prejudice, toxicologists admit to-day, with just reason, that copper salts are but slightly poisonous. Dr. Galippe has shown that 50 centigrammes to 1 gramme of copper salts may be swallowed daily without fatal accidents. Workers in copper, those who work in verdigris factories, show no signs of poisoning even if, owing to the daily absorption of copper, their hair, nails, and skin turn green, a colour which, according to Petri, is produced by the deposit of microscopic salts of copper. The copper daily absorbed would rather, according to Dr. Pecholier, have a beneficial effect on the organism, an effect analogous to that which is produced by iron salts. He has remarked that chlorosis never exists in workmen engaged in verdigris factories, and that workmen, anæmic when they entered, were quickly cured of that complaint. The fear expressed formerly that the treatment of vines by copper salts might introduce into the wine poisonous substances injurious to the consumers is not, therefore, justified. The doses borne by the human organism are much greater than those which could be absorbed in articles of diet containing copper. Different fruits treated with copper have been absorbed without inconvenience (Fairchild). Moreover, 1 kilogramme of grapes, which came from a vine treated with bouillie bordelaise in autumn, only contained 17-35 milligrammes of copper, whilst preserved green peas contain 11-125 milligrammes ; the amount found in the wine is still less. According to the analysis of Crolas, Raulin, Gayon, Millardet, Muntz, and Rossel, the maximum of copper found in wines, from vineyards treated with copper bouillie, was from 2·5 milligrammes per litre in red wines and 1 milligramme in white wines ; in the greater

number of wines the average amount of copper does not reach one-hundredth of a milligramme. This amount of copper, contained in wines, comparatively small in comparison with that which enters into the vat, arises from the fact that the copper remains insoluble in the lees. To prove it, it suffices to place a handful of blue vitriol in the vat; the copper will remain in the lees and not pass into the wine. The tables prepared by Crolas, Raulin, as well as by Millardet, show this fact decisively.

TABLE XXV.—*Showing the Distribution of Insecticidal and Anticryptogamic Copper between Wine, Lees, etc.*

	Copper in lb. per 100,000 *Gallons or* 1,000,000 *lb. of Wine.*			
	Wine.	*Picquette.*	*Marc.*	*Lees.*
1 lb. blue vitriol in 40 gallons water	0·23	0·00	11·0	49
1 lb. blue vitriol, 1 lb. ammonia in 40 gallons of water, eau celeste .	0·25	0·14	12·8	81
6 lb. blue vitriol, 15 lb. lime in 10 gallons water, bouillie bordelaise .	0·00	0·1	10·4	92

The different parts of the vine treated by a copper bouillie contain the following amounts of copper in milligrammes per kilogramme: leaves 24·9-95·5; stem and wood, 5·8; grapes, 15·9-18·6; marc, 11·1-29·9; wort, 1·0-2·2; wine, 0·1. The amount of copper entrained into the wine is so small that it does not even interfere with the fermentation. The development of the ferments is not hindered up to 0·3 gramme of blue vitriol per litre (Rommier), a dose, therefore, which can never occur in wine. It must, therefore, be admitted, that before the action of copper can make itself felt, a man must absorb several hundred litres of wine a day.

Action of Blue Vitriol on Plants.—To ascertain the action of a soluble salt on a plant the latter is grown in an artificial medium containing a known dose of the salt to be examined. Haselhoff found that the greater number of plants suffered in such conditions from a small dose of blue vitriol. According to him the dose of 0·001 per cent is injurious in almost all cases, but the deadly action of blue vitriol already shows itself in presence of 0·0005 per cent with certain plants, and even with 0·00011 per cent (Devaux). Normal growth is impossible, except in presence of much weaker doses of blue vitriol. Thus peas grow normally in a 0·00005-0·000001 per cent solution. Maize grows in a 0·000005-0·0000001 per cent solution. Grain only stands very weak doses of sulphate of copper; the young plant is killed by 0·004875 per cent of copper bromide, 0·005 per cent of copper chloride, 0·00555 per cent of copper sulphate, 0·005714 per cent of acetate of copper, 0·0061 per cent of copper nitrate. It follows from these experiments that copper salts are violent poisons to plants when the roots are in presence of their solutions. Coupin's

table proves that copper salts do not act through their acids, as Monselice asserts, but by their copper. The following are the successive phases through which a plant, placed in a medium containing a poisonous dose of blue vitriol, passes: If a branch of cryptomeria, of Pinus or of Thuya, is dipped in a 0·01-0·05 per cent solution of sulphate of copper, the chlorophyll contracts and ruptures and the interior of the cell browns. If young plants be placed therein the roots at first turn white, then become yellow and brown, grow up abnormally, then die. By analysing the different organs of a plant killed by a solution of blue vitriol, Devaux found traces of copper in all its parts. R. Otto, who submitted some plants (*Phaseolus vulgaris, Triticum vulgare, Zea Mays, Pisum sativum*) to the action of blue vitriol in a nutritive solution, found, on the other hand, that these, in spite of the deformation of their roots and their diseased state, only contained a very little copper in the roots and none at all in the aerial parts. Hence he concluded that blue vitriol is so poisonous to the plant that as soon as it has penetrated into the cells of the root it there occasions such disturbances that the plant dies before it can be conveyed further.

This conclusion may be a sound one when the plant is placed in contact with large quantities of a copper soluble salt, because in such conditions the living cell is opposed to the osmosis of the salt. Nageli also believes that blue vitriol kills the cell as soon as it is absorbed by it, but that the latter does not suffer so long as it can prevent its penetration. Nägeli experiments on a green, fresh-water alga, Spirogyra, which possesses, like phanerogams, chlorophyll and plasma, showed that a solution of blue vitriol of 1 part in 100,000,000 sufficed to cause the death of this alga. The effects produced on the chlorophyll and the plasma are very visible under the microscope. The conditions which we create artificially in a culture liquid do not exist, however, on the large scale, and it would be rash to conclude by analogy that blue vitriol acted in the same way on plants grown in the open field. If the soil be watered with a solution of blue vitriol, chemical reactions are produced between this salt and the soil which convert this soluble salt into one or more insoluble compounds, and copper salts being more poisonous the greater their solubility, insoluble salts such as oxide of copper have no action on the plant. It is not necessary to go far to find an analogous example. Mercury as bichloride, a soluble salt, poisons man even in very small quantity. It no longer has any injurious action when it is absorbed as calomel, an insoluble product. These two salts, however, possess the same elements, chlorine and mercury, but their different action on the organism lies in the fact that corrosive sublimate, being soluble, coagulates albumen, whilst the insoluble calomel passes through the organism without causing any trouble. Similarly the plant shows signs of poisoning in presence of blue vitriol, because the latter is soluble and capable of producing copper albuminates, but it remains indifferent to the presence of insoluble copper compounds on the large scale. When solutions of blue vitriol are spread round a plant this salt all falls into the soil, and the roots are no longer in contact with a poisonous and corrosive liquid

but in presence of an insoluble compound. The plant will absorb the homœopathic quantities which are beneficial to it, dissolving them by means of the acid juices of its roots, by its chemical and physiological exertions. The soil is capable of absorbing enormous quantities of blue vitriol without the latter injuring the plant (the soil naturally contains copper; Vedrosi found in arable land 0·01-0·15 per cent of copper oxide, the average amount is from 0·06-0·08 per cent). Viala watered vines in pots regularly for three months with a solution of blue vitriol and mixed in this soil the dose of 200 grammes of this salt without the vine perishing. Girard cultivated rye, oats, clover, and potatoes on a soil treated with 1½ metric tons of blue vitriol per hectare (1320 lb. per acre). Taft concludes from his experiments that the soil does not refuse to grow plants until it contains 1 per cent of copper. To prove that copper sulphate incorporated in a soil is no longer soluble, Gorup-Besanez watered 240 cubic centimetres of soil with a 0·1 per cent solution of blue vitriol. This soil, washed at once with 500 cubic centimetres of water, gave up no trace of copper to the water. Similarly, Nobbe, who watered 152 grammes of dried soil with 150 grammes of blue vitriol was only unable to recover with 2 litres of water 7·1 per cent of the blue vitriol used. In practice it has been found that the watering of plants even with comparatively strong solutions of blue vitriol is far from being injurious. On the contrary, it is salutary. Rumm and Pichi found that vines watered with 5 per cent solutions of blue vitriol, when the sap begms to circulate, resist mildew and show a certain immunity to cryptogamic diseases. But the amount of copper must not be too small; 5½ gallons per stock of a 1 per cent solution do not prevent mildew from attacking the vine. But complete immunity is obtained with 5½ gallons of a 5 per cent solution. Besides this immunizing action blue vitriol possesses a stimulating power on all the vital functions of the plant, like green vitriol; plants become vigorous, their leaves more fleshy, of a deeper green, and the vitality of the plant is prolonged. Hence it may be concluded that the vine is capable of absorbing copper by the roots. Is that possible?

As far back as 1819 John experimented on the absorption of copper by the roots. By mixing carbonate of copper with the sterilized sand used for his cultures he could not find the presence of an abnormal quantity of copper in the ash of the experimental plants. But when these plants were watered with very small quantities of nitrate of copper, the copper absorbed by the roots was ponderable. Peas cultivated in this medium contained in their ash sufficient copper to give a red precipitate with yellow prussiate. The ash of barley, cultivated in the same condition, contained it in such large amount that it could be precipitated and estimated by iron. Buchhloz and Meissner also found that roots could absorb copper under a form which it has not yet been possible to define. Tschirch has shown that the potato absorbs the copper applied to the soil, even though the latter is watered with 4 kilogrammes (8·8 lb.) of blue vitriol in solution per 2 cubic metres of earth. The amount of copper absorbed is the greater the larger the proportion of copper applied. These results also confirm the fact that

copper is present in all plants, as it is recovered in their ash. Potatoes contain 0·0028 grammes per kilogramme[1] (Deschamps), haricots 0·002-0·011 grammes per kilogramme (Galippe), chicory, salad, spinach, and clover also contain it, likewise the vine, the fig, and the plum (Papasogli). A certain amount is found in beet (Langlois), in pepper (Meissner), and in tobacco (Wicke). Vedrosi found 0·06 per cent of copper oxide in oak wood, 0·02 per cent in the leaves, 0·04 per cent in the glands; in haricots the proportion is greater, and reaches 0·38 per cent; in rye 0·19 per cent; in wheat 0·21 per cent; in barley 0·12 per cent; in oats 0·35 per cent; in maize 0·39 per cent. Whence comes this copper if it were not absorbed by the roots? This belief, shared by De Candolle (1832), Francis Phillips (1882), Freytag (1882), and others, has been disputed by many physiologists, who, for one reason or another, have not found in plants treated with copper sulphate a ponderable amount of copper, or who have found that blue vitriol was too poisonous to be entrained through the plant like nutritive salts. Pichi, on the other hand, claims to have identified, under the microscope, crystals of copper in the mesophyll of the leaves of plants watered by blue vitriol, and Devaux's experiments prove that copper, in an insoluble form, put in contact with the roots or the leaves, is assimilated by them in infinitesimal quantities and carried through the plant under the form of an organic compound, capable of forming deposits in the cellular membranes. The difference of opinion arises in the analytical processes which have been adopted for the detection and estimation of copper in the sap or in the ash of plants. It is wrong to try to determine in all cases the amount of copper by chemical or physical methods, because they are not sensitive enough. The amount of copper is often so minimum that it escapes detection by the chemist. Deherain advises recourse to the extreme sensitiveness of the alga spirogyra, which is affected by the dose of 0·000001 per cent of blue vitriol. Ewert found a more sure method, based on the presence of diastase, that is to say, on the stoppage produced in the conversion of starch in presence of diastase, by infinitesimal doses of blue vitriol, a method by which 0·00000051 milligramme of blue vitriol may be detected. If plants are visibly healthy after watering with copper salts, that results from the absorption of very small quantities of copper that can only be determined by these latter methods of analysis. It suffices to consider the infinitesimal doses of inorganic salts required to exert a stimulating effect on the human organism to understand the rôle which copper plays in the plant.

The question then appears in quite another light, and it is in homœopathic doses that soluble copper salts must be given to plants, unless reserves of copper be formed round the roots of plants and on the aerial organs with strong doses of insoluble or very slightly soluble compounds. Wuthrich was the first to point out the analogy which exists between the action of green vitriol and that of blue vitriol, and that of corrosive sublimate on the spores of fungi. The physiological effect produced on plants is likewise the same, since these three

[1] = oz. per 1000 oz.

compounds are capable of coagulating albumen and other nitrogenous substances with which the life of the plant is intimately linked. The intensity of their toxic action is in inverse proportion to their atomic weight; but keeping to these proportions blue vitriol is ten times more energetic than green vitriol, and mercuric bichloride 100 times more active than the last. The same holds good as regards the stimulating effect, that is to say, that to increase the assimilation in a plant it requires 100 times less mercury and ten times less copper than of iron. These salts are, moreover, not the only ones capable in small doses of stimulating the vital functions of the plant. M. N. Ono found that poisonous salts, such as zinc sulphate, cobalt sulphate, sodium fluoride, and nickel sulphate, had in small doses lost their poisonous properties and become stimulants. Raulin found the same with salts of zinc and of silicium.

In practice it has been found that blue vitriol may render the same service as green vitriol, but that for this purpose it must be used in much smaller quantity. The analogy between the action of these two salts is so striking that it has been seriously a question of attributing this action to the green vitriol, very often present in commercial blue vitriol; they have even gone so far as to advise the addition of a little green vitriol to blue vitriol to increase its stimulating action. A manifest error was thus committed, which will be dealt with when the action of bouillie bordelaise on the plant is considered. By watering the aerial plant the same results were obtained as by watering the roots, that is to say, the vital functions of the plant were stimulated. But if large surfaces be placed in this way in contact with a soluble salt of copper, the poisonous effects are felt more, and leaf scald results from the too large quantities of salt absorbed. If it be evident that the sulphuric acid of the blue vitriol, when liberated by certain reactions, may exercise its well-known corrosive action on the organs touched, the poisonous action of blue vitriol is especially due to the copper which, absorbed by the leaves as sulphate of copper, kills the cells of the organs traversed. These drawbacks still occur, even with 0·1 per cent solutions. Owing to this annoying effect sprayings with blue vitriol have been abandoned, and given place to copper bouillies. The latter, which contain copper in an insoluble form, copper hydrate, or carbonate, produce on the leaves an insoluble deposit, of which the latter can absorb the amount beneficial to them. Thus there are realized on the leaves the conditions created around the roots by spraying with blue vitriol. From the foregoing it follows that blue vitriol is a violent poison to plants, and that its contact, always injurious to the plant, should be avoided. Neither blue vitriol, nor any of the other neutral salts of copper, is the suitable copper compound to be applied to plants. The pollen of flowers being very sensitive to the action of copper salts even when insoluble, forbids their application during the flowering of the plant. Miani found pollen to have the same sensitiveness as fungi spores, but that an infinitesimal amount of copper salts stimulated their vitality.

Action of Blue Vitriol on Algæ and Saprophytic Fungi.—Saprophytic fungi and algæ behave to blue vitriol like phanerogamous

plants; stimulating in small doses blue vitriol is poisonous in large doses. It is to be remarked that blue vitriol shares this stimulating action on algæ with many other poisonous salts. Raulin remarked in 1869 that zinc and silicium salts increased the vitality of the fungus *Aspergillus niger*. Nägeli, Pfeffer, and Richards made the same remark on zinc, nickel, and cobalt salts, used on the fungus *Aspergillus niger* and *Penicillium glaucum*, and on the algæ *Protococcus*, *Chroococcus*, *Stigeoclonium*, and *Hormidium*. The vitality of fungi and algæ is, to sum up, stimulated by the sulphates of zinc, nickel, cobalt, iron, and copper, mercuric chloride, sodium fluoride, lithium nitrate, potassium arseniate. The right dose for algæ is smaller than for fungi. For blue vitriol the maximum dose is 0·012 per cent; for mercuric chloride 0·0013 per cent. Ferments (leavens) behave in the same way as fungi. According to Kruger the alcoholic fermentation of wort by *Saccharomyces ellipsoides* is favoured by doses of blue vitriol smaller than 0·01856 per cent. Pichi and Rommier found that a solution containing 0·015 per cent of blue vitriol began to impede fermentation and that 0·03 per cent reduced it perceptibly. Besides copper salts are precipitated by fermentation, the ferments can thus find in the lees the amount of copper favourable to their development (Biernacki and Kruger). There are, however, exceptions amongst plants. Thus the fresh-water algæ spirogyra dies in a solution containing only 0·000001 per cent of blue vitriol (Nägeli), whilst other algæ resist solutions of 0·012 per cent perfectly. *Penicillium glaucum* would even be capable of growing in a concentrated solution of green vitriol. This fact, remarked by Trabut, was examined by De Seyes. In a nutritive solution blue vitriol does not disturb the growth of *Penicillium glaucum* (Trab.) in a 9·5 per cent dose. This fact must, however, be considered in another light to understand it. It is, in fact, recognized that *Penicillium glaucum* can grow in a poisonous medium without feeding on its elements, but by using the medium solely as a support. Hence this mould is perfectly capable of growing on a crystal of nitrate of silver, or in a solution of 1 per cent of corrosive sublimate. Whilst germinating spores of *Penicillium glaucum* in a 9·5 per cent solution of blue vitriol, De Seyes observed that growth did not occur except on the edge of the vessel, where the water of condensation was accumulated. Saccardo stopped all growth of this fungi in a medium containing 5 per cent of blue vitriol by agitating the solution; whilst at rest growth was so normal that it formed *conidiæ*. *Penicillium* therefore does not possess a special immunity for copper salts, as had been imagined, but behaves like other fungi, and R. Otto gives the dose of 0·008 per cent as favouring its development. This dose is hardly greater than that required by *Aspergillus niger*, 0·004 per cent.

Action of Blue Vitriol on Parasitic Fungi.—Benedikt Prevost, in 1807, discovered the poisonous action of blue vitriol on parasitic fungi. In his experiments to determine the action of boiling water on spores, he made the sensible remark that water boiled in a copper vessel alone had the power to prevent spores from germinating. He then determined that it sufficed for the water to contain 1 part in 400,000 of its weight of blue vitriol to prevent the spores of rust from

germinating. The study of this phenomenon was pursued by Mathieu de Dombasle. In 1858 Kuhn examined the comparative action of blue vitriol and green vitriol, alum and sulphuric acid on the spores of rust, an examination which still throws light on the remarkable properties of blue vitriol. In 1885 Millardet found the limit of toxicity of blue and green vitriol on the zoospores of mildew, and found that these could still germinate in a solution of 1 of lime to 10,000 parts of water, of 1 of green vitriol to 100,000 parts of water, and 1 of blue vitriol to 10,000,000 parts of water. In 1889 Dufour examined the action of blue vitriol on the spores of *Fusicladium pirinum*, *Claviceps purpurea*, *Pleospora*, *Phragmidium*, and other fungi, and found that the germination was normal in a solution of 1 in 1,000,000, reduced 1 in 100,000, rare 1 in 10,000. In 1891 Wuthrich tried, comparatively, potassium nitrate, sodium carbonate, zinc sulphate, zinc chloride, copper sulphate, and mercuric chloride on the spores of *Peronospera*, *Phytophthora*, *Ustilago*, *Puccinia*, and *Claviceps*, and made very instructive conclusions. Tried on the spores of the most diverse fungi, blue vitriol has been recognized as possessing a highly extensive poisonous capacity and capable of combating the greater number of the cryptogamic diseases of plants. Wuthrich was the first who described the action of blue vitriol on spores. He determined the similarity in the action of different salts, and particularly in that of blue and green vitriols. It has already been pointed out that their action on spores appears to be inversely proportional to their chemical equivalent, but that blue vitriol, regard being had to these proportions, was ten times more energetic than green vitriol. Wuthrich found that these two salts penetrated into the spores, and that death only supervened after this penetration, whilst blue vitriol could be detected in the cell by yellow prussiate, even in the case where a spore had only undergone a slight alteration in its vitality in contact with this salt. It is not the same with copper, which cannot be detected chemically in the same condition. Spores that have been steeped in a solution of blue vitriol of 0·0001 equivalent per litre, a dose which appreciably affects the vitality of the spores, absorbs so little copper that its presence in the cell cannot be demonstrated by a chemical reagent. The solution in the bath itself, moreover, gives no perceptible tint with prussiate. It is different when the spore dies as the effect of steeping in the solution of 0·001 equivalent per litre; in these conditions the dose of copper is sufficient to give a coloration with prussiate. Wuthrich concludes, therefore, that a certain dose of blue vitriol may be absorbed by the spores without killing them, but that this dose does not exceed a certain limit. The table on p. 210 shows how the spores of different fungi behave after being steeped in a dilute solution of blue vitriol.

Hecke, examining the action of blue vitriol on the spores of *Ustilago Crameri* found that 0·125-1 per cent of blue vitriol did not kill the spores, even those which had manifestly absorbed copper. A subsequent washing of the spores with water in no way changed the effect of the treatment, as is the case with spores treated with formol, but washing with 0·5 per cent HCl reimparted to them all their vitality.

TABLE XXVI.—*Showing the Effect of Solutions of Blue Vitriol of Various Strengths on the Germination of Spores of Fungi.*

Spores of	*Germination Normal Per Cent of Solution.*	*Germination Abnormal Per Cent of Solution.*	*Germination Nil Per Cent of Solution.*
Phytophthora infestans . . .	0·000125	0·00125	0·0125
Peronospora viticola . . .	0·000125	0·00125	0·0125
Ustilago carbo	0·000125	0·0125	0·125
Puccinia graminis . . .	0·000125	0·0125	0·125
Claviceps purpurea . . .	0·000125	—	0·0125

In 0·125 per cent solutions of blue vitriol the copper disappears in five minutes' immersion, and is fixed on the spores. Spores of different species of smuts behave differently from this point of view.

Ustilago Panici-miliacei.—0·5 gramme of spores absorbs all the copper from 5 cubic centimetres of a solution of 0·125 per cent of blue vitriol. 0·5 gramme of spores absorbs all the copper from 10 cubic centimetres of a 0·125 per cent solution of blue vitriol. 0·5 gramme of spores absorbs almost all the copper from 15 cubic centimetres of a 0·125 per cent solution of blue vitriol.

Ustilago Crameri.—0·5 gramme of spores absorbs all the copper from 5 cubic centimetres of a 0·125 per cent solution of blue vitriol. 0·5 gramme of spores absorbs almost all the copper from 10 c.c. of a solution of 0·125 per cent of blue vitriol. In the filtered liquid only sulphuric acid (dilute) remains. The spores treated by 0 5 per cent hydrochloric acid cede the whole of their copper to this acid and recover their original vitality. Blue vitriol acts, therefore, like formol, by fixing itself on the chitinous membrane of the spores of fungi and preventing their growth ; treated by an acid this compound disappears, and the vital functions resume their natural course as before treatment with blue vitriol. It is not therefore surprising that blue vitriol cannot be detected in the interior of the cells by chemical reagents, since in small dose it does not penetrate but is retained on their surface. Although blue vitriol in small doses does not kill spores it prevents their normal evolution and the object sought is found. The plant is safe. The dose of blue vitriol, therefore, required to prevent the growth of spores is very small, and it is not difficult to produce this effect, since by spraying with copper bouillies the plant is covered by a layer of a slightly soluble copper compound.

Action of Blue Vitriol on Insects.—The larvæ of insects with a wet skin are as sensitive to blue vitriol as snails. The adult insects may be poisoned by absorption from the leaves sprayed with copper compounds. The eggs of insects are much more insensitive to copper salts than is generally believed, and to destroy them they require steeping for a very long time in a strong solution of blue vitriol. Perroncito has shown that the eggs of silk-worm (*Bombyx Mori*) easily resist a twenty-four hours' immersion in a bath of 1-2 per cent of blue

vitriol. In the same way caterpillars are not inconvenienced by contact with blue vitriol solutions. Dufour found that a 10 per cent solution did not incommode the caterpillar of the *Cochylis* of the vine. Mouillefert immersed vine roots bearing numerous phylloxera for three days in a saturated solution of blue vitriol and still found many living insects; it was only after five days' immersion that all the phylloxera died. The great resistance of this louse is, therefore, the cause of the bad results obtained with the different processes of destruction recommended in 1872 and submitted to the control of a special commission. If blue vitriol cannot be regarded as a poison by contact, it, however, becomes poisonous when absorbed by the leaves, and the favourable results obtained by the bouillie bordelaise admit of no doubt in the matter. Besides, insects avoid gnawing the organs touched with blue vitriol, and are thus removed by spraying. Targioni Tozzetti, having steeped potatoes in a solution of blue vitriol, found that the larvæ of the *Elaterides* did not touch them. In this way Angelo met with complete success against the phylloxera in the island of Elba, by injecting blue vitriol into the diseased stocks. Dying vines revived by this treatment, for the phylloxera disappeared from the stocks treated.

Use of Blue Vitriol to Kill Weeds.—Amongst chemical weed killers, blue vitriol is one of the most efficient. Bonnet, a vine-grower, found it out fortuitously. He observed that the mustard which grew amongst the vines was destroyed by blue vitriol, whilst oats, growing in the same condition, were immune. Trials made by Benard and Brandin showed that a 5-10 per cent solution of blue vitriol disorganized the cruciferæ growing amongst cereals without injuring the latter. Its disorganizing action is more powerful than that of green vitriol. Whilst it requires 15-20 per cent of this latter salt, 4-5 per cent of blue vitriol suffices to produce the same effect, at the rate of 44-88 gallons per acre (Dussere). It is better to use mixtures of blue vitriol and nitrate of soda as weed killers. The young plants are destroyed by a mixture of 2 per cent of blue vitriol and 10 per cent of nitrate of soda, sprayed at the rate of 8-10 hectolitres per hectare (70·4-88 gallons per acre).

Use to Destroy Parasitic Plants.—*Cuscuta minor*, D. C. (small dodder of the lucerne and clover); *Cuscuta densiflora*, Willm (dodder of flax); *Cuscuta major*, D. C. (large dodder of the hop and hemp plant).—Blue vitriol kills dodder in much smaller doses than green vitriol. From 2-5 per cent solutions of blue vitriol suffice. Their method of use is the same as for green vitriol.

Orobanche ramosa (branchy orobanche of hemp and tobacco); *Orobanche minor* (clover orobanche).—Gennadius advises to destroy these parasites by a 5 per cent solution of blue vitriol, which destroys their seeds.

Use against Mosses and Lichens.—Coating with a mixture of 6 per cent of blue vitriol and 2 per cent of sulphuric acid readily destroys the mosses and lichens which grow on the trunks of trees.

Use against Cryptogamic Diseases of Plants.—*Phytophthora infestans*, De By. (potato disease).—The analogy between the *Phytophthora* and the *Peronospora*, combated with so much success by copper salts, led to the belief of an analogous efficiency of these in

preventing the potato disease. However, numerous experiments with this end in view gave less decisive and less concordant results than with mildew of the vine, but there is now no doubt that the methods used to prevent mildew of the vine are equally efficacious to avoid the *Phytophthora*. Petermann, after three treatments, only obtained 35·960 kilogrammes of potatoes instead of 46·370 on an untreated plot amongst which there were only 2·5 per cent of diseased potatoes against 11·3 per cent in the check plot. Montanari found that there were as many diseased tubers in the fields, sprayed with 0·25, 0·5, and 1 per cent solutions of blue vitriol, as in those untreated. These results show that the method of application has a great influence. Frank and Kruger have shown, on the contrary, that a general preventive and judicial treatment of the potato increases its assimilative capacity, which is manifested by an over-production of potatoes rich in starch, but that it is necessary to choose other compounds than blue vitriol to attain this end, the scorchings occasioned by sprayings of blue vitriol, to which the potato is more sensitive than the vine, being often the cause of smaller crops of tubers.

To produce this favourable result it must not be forgotten that the infection of the potato may be produced either by conidia, brought on to the leaves by the wind, or by previous infection of the tubers. To be complete, therefore, the treatment ought to be double. (1) Disinfection of the seed tubers, four to five weeks before planting, so as to prevent the propagation of the disease by the tubers. (2) Repeated preventive spraying with copper preparations against the aerial invasion. The cupric treatment which can prevent the rapid progress of the disease, and its extension in potato fields, by annihilating the conidia produced during summer, can in no way destroy the mycelium which lives in the interior of the leaves and the stems, nor prevent the progress of the disease on the infested tubers. The treatments must therefore be preventive and capable of killing the conidia or the zoospores which fall on the leaves, so as constantly to oppose the invasion of the plant by this disease. By observing all these necessary conditions the cupric treatments are crowned with the same success as the preventive treatment for mildew of the vine. This point will be dealt with more fully in describing the treatment of *Phytophthora* by bouillie bordelaise. This latter, used judiciously, is so superior to blue vitriol that the latter has been abandoned. Sorauer recommends "cupric-sulfosteatite," a mixture of 10 per cent of blue vitriol and 90 per cent of talc, to combat the disease of the tomato. This preparation is added to the manure and sprayed at intervals of four to five days, and after transplanting every eight to ten days. Care must be taken not to use too much, for it may scorch the plant. Used against the potato disease, sulfosteatite has given results varying from one species to another. Whilst Liebscher declares that its use lowered the crop 31 per cent and Steglich found it without action, Schoyen, Hollrung, and Strebel obtained in many cases superior yields up to 26·3 per cent. All are, however, agreed that its results are not so regular as those obtained with neutral bouillie bordelaise.

Peronospora viticola, De By. (mildew of the vine).—Owing to

its purely aerial propagation the mildew of the vine is much easier to destroy than the *phytophthora*. It suffices to prevent the disease to stop the zoospores from germinating by poisoning them. There can be no question of destroying the mycelium in the tissue of the leaves, and if the disease has invaded the plant the treatment must be confined to preventing the propagation of the disease to neighbouring plants by the conidia coming from the plant attacked. Cupric preparations, by depositing on the leaves an adherent and slightly soluble layer, creates an insurmountable barrier to the spores of this fungi. As 2-3 ten-millionths of this salt soluble in the dew suffice to prevent the zoospores from germinating, it will be seen that the layer of the cupric compound lying on the leaves will always cede this amount to the water deposited on the leaves. The most active and efficient preparations are, therefore, those which possess a very weak solubility with perfect adherence. Blue vitriol is the copper salt which realizes these conditions to the least extent; it has therefore been replaced by the bouillies which give much better results and never injure the vine. When in 1884 it was seen in Burgundy and Maconnais vineyards, ravaged by the *Peronospora*, that certain stocks preserved a normal appearance, it was found that those which were exempt from the disease were attached to new props, impregnated with blue vitriol to preserve them. This observation was communicated to the Academy of Science by Perry, who observed it himself in the department of Saone et Loire.

Experiments were made the following year by Paulin, using vitriolized props throughout a whole vineyard, and by Prosper de Lafite, by simply steeping the ropes of straw or willow skins in a bath of blue vitriol. But these experiments were soon followed by a bolder and more rational treatment, consisting of spraying with more or less dilute solutions of blue vitriol on the foliage of the vine. These treatments, which enabled the invasion of mildew to be victoriously contended against, were, however, far from giving entire satisfaction. The proportions of blue vitriol used in the beginning were from 1-15 per cent. In 1885 Muntz recommended the treatment of this disease by 10 per cent solutions of blue vitriol. But there followed scorchings of the leaves; it is true they were not serious, but all the same alarming. The doses were reduced, owing to these mishaps, to 3 per cent, then to 1 per cent, and then by Bouchard and Beaume to 0·3 per cent. With this dose Ricaud got the same preservative result as with the larger doses. In spite of this small dose of blue vitriol the vines showed the same characteristic burning, especially when the spraying was done in hot, warm weather, because the drops of this dilute solution deposited on the leaves concentrated rapidly, and then acted like a concentrated solution. Blue vitriol, used against vine diseases, possesses two defects: (1) injuring the foliage, (2) possessing no adherence on the leaf; rain removed all the blue vitriol deposited thereon. To obtain with these solutions the same effect as with bouillies, it would be unceasingly necessary to multiply the treatments, and in these conditions the advantage of blue vitriol being cheaper, as compared with bouillies, entirely disappears. Blue vitriol sprayings have also the drawback of leaving no visible trace on the leaves, whilst bouillies

enable the work to be controlled owing to the blue spots which they leave on the organs touched. In spite of these drawbacks blue vitriol is still used in 0·25 per cent solution in Le Tarn, owing to the low cost of the spraying. To give adherence to blue vitriol Trabut advises to add mucilaginous substances to its solutions; the mucilage extracted from the prickly pears of the Barbary fig-tree, and galipot, a dry resin which exudes the whole length of the Algerian pines, previously dissolved in carbonate of soda. The galipot soap bouillie has the following composition: galipot, 1 lb. dissolved in $\frac{1}{2}$ lb. of soda crystals; blue vitriol, $\frac{1}{2}$ lb.; water, 10 gallons. The bouillie with the Barbary fig mucilage basis is made thus: 3-5 lb. of the prickly pear of the Barbary fig are cut up and macerated in water. After extraction of the mucilage $\frac{1}{5}$-$\frac{1}{3}$ lb. of blue vitriol is added and the mixture made up to 10 gallons. These preparations effect a saving of 50-80 per cent of blue vitriol and are cheaper in Algeria. They are to be recommended in countries where rain is rare, and where the number of sprayings necessary do not exceed those with bouillies. Viala's, Pichi's, and Rumm's experiments show that mildew may be contended against by spraying round the stocks with blue vitriol solutions; this salt would therefore possess serious advantages over bouillies. Unfortunately the doses required to obtain immunity are such that there can be no question of employing this treatment on the large scale. From experiments of Chmjelewsky it follows that blue vitriol has a deadly action on fructification. Beach and Bailey also found that it was deadly to pollen; 0·02 per cent solutions lower its vitality, and it is killed when it comes in contact with 0·5-2 per cent solutions. If the flower be open for some days only before the treatment the action of the blue vitriol is less injurious. Spraying with blue vitriol should thus be avoided during flowering if it is not desired to do great damage to the crop.

Use of Mixtures containing Blue Vitriol.—As the vine-grower already was accustomed to distribute flowers of sulphur with a bellows to contend against oidium, the operation of treating the mildew would have been greatly simplified if it had been possible to use blue vitriol in a pulverulent form mixed with sulphur. A great number of analogous mixtures have been compounded in different countries. They either contain blue vitriol mixed with powdered inert bodies, or are the elements of cupric bouillies with or without sulphur. With some rare exceptions, the adherence of these is much less than that of cupric bouillies which renders them liable to be carried off by the wind and by the first rain. It is also necessary to apply them in the dew of the morning, so as to render them a little more adherent. It will be seen, therefore, that these preparations cannot be regularly used except in moist countries, and that those which contain sulphur cannot produce on the oidium the categoric effect of sulphur alone used at a full heat. To increase the adherence of blue vitriol on the leaves it has been mixed with substances like talc, powdered coal, alumina, sulphate of lime, and sugar, or it has even been dehydrated and reduced to an impalpable powder by calcination. The latter preparations are the only ones of any real use in certain circumstances. Powders consisting of pulverized blue vitriol and various other bodies, mixed by grinding,

are defective from the fact that projected on to the plant, the different densities of the products of which they are composed produces a separation, causing an irregular distribution of the blue vitriol. On the other hand, powders prepared like "Cupric Sulphosteatite" do not possess this drawback. Besides this drawback preparations which contain blue vitriol have all the defects of its solutions. These drawbacks make themselves felt when it is a question of using these powders against the cryptogamic diseases which affect delicate plants. The intense scorchings may have disastrous effects from the point of view of the yield of the plant. But the powders are easily distributed, and that is their great advantage. Their judicious use in special cases may save a vineyard from a sudden attack. The grower sometimes uses powders which enable him to dispense with bouillies, and when the vineyard is far from a dwelling, extensive, and without water, the carting of the necessary water to manufacture these bouillies. The appliances used are those utilized for sulphuration. However, as blue vitriol attacks leather, only bellows with exterior case can be used. In spite of the numerous disadvantages of powders many vine-growers have adopted the cupric sulphosteatite, which is the best of all these preparations. They use it at the same time as the bouillies, but this powder ought not in general to be used, except as a supplement to liquids, when the foliage is so thick that it prevents the uniform penetration of the bouillies. It is good to protect grapes for it penetrates more readily amongst the grapes as compact grains. Exact details will only be given of one of the preparations of this sort, the *cupric sulphosteatite*, compounded, like Fostite's powder (*Poudre Fostite*), of blue vitriol 10 per cent, talc 90 per cent. It is prepared by pouring on the talc in powder a saturated solution of blue vitriol. The resultant paste is dried, ground, and sifted. It is a bluish powder, which, owing to its lightness, penetrates as far as the interior of the vines with the most dense foliage. Used in the morning dew its adherence is so good that traces of it may be seen two months afterwards, even when violent storms have washed the leaves. Owing to this property it has given perfect results at Montpelier in assuring complete preservation of the vine. It has been especially recommended for destroying the mildew of grapes, for owing to its tenuity it penetrates everywhere, and the rapidity with which it can be applied enables the crop to be saved at the time of a sudden invasion. If it be desired to use it alone for mildew (which cannot be advised in spite of its properties, for bouillie bordelaise is still superior), three applications are necessary, at the rate of 20-25 kilogrammes per hectare (17·6-22 lb. per acre). The first should be done eight days before flowering, the second five weeks after the first, and the third in the middle of July. If there be mildew in the neighbourhood, and late invasions to be feared, supplementary applications must be given. Pulverizations with powders containing blue vitriol are always injurious when they are made during flowering. Amongst the numerous preparations on the market the following may be quoted as intended for making bouillies by mixing them with water, or to be pulverized such as they are by aid of a bellows. Their composition has been given by Barth, of Colmar:—

Poudre "Coignet".—Intimate mixture of 10 per cent blue vitriol and 90 per cent of gypsum, recommended by Klening and Wuthrich against *Phytophthora.*

Sulfatine.—Mixture of 73 per cent sulphur, 7 per cent blue vitriol, and 20 per cent of lime; used in America against the black rot.

Kupferschwefelkalk, mark CuSCa.—Mixture of 70 per cent of sulphur, 6 per cent of blue vitriol, and 24 per cent of lime, recommended in Germany by Schoyen to contend against mildew of the vine and oidium, and even *Phytophthora.* It has little adherence (Thiele).

Bouillie bordelaise celeste in a single powder.—Mixture of 49·74 per cent of blue vitriol, 15·1 per cent of lime, and 35·16 per cent of carbonate of soda.

Skavinsky's Powder, consisting of blue vitriol 20 per cent, lime 6 per cent, ground coal 74 per cent.

Skavinsky's Sulphur.—Blue vitriol 10 per cent, sulphur 50 per cent, lime 3 per cent, powdered coal 37 per cent. These two powders can only be used as supplementary applications when the foliage is too dense. They adhere badly.

Kupfer Klebekalkmehl.—1896-7 *Preparation*—Blue vitriol 26, argillaceous clay 74 = 100 calcine. 1898 *Preparation*—22·5 per cent of blue vitriol are neutralized by carbonate of soda and mixed with oxide of alumina and china clay. This latter preparation is very adhesive, and is used for making bouillies.

Kupferzuckerkalkpulver.—Calcined blue vitriol 40 lb., powdered slaked lime 50 lb., powdered sugar 10 lb. = 100 lb. mix.

Cuprocalcit.—Blue vitriol 20-25 lb., argillaceous carbonate of lime (? marl) 75-80 lb., per 100 lb. It is used in the dew, or as a bouillie, 1 lb. to $1\frac{1}{2}$ gallons water. To strengthen its action it is recommended to add $1\frac{1}{2}$ gallons of ammonia to 100 gallons of bouillie.

Cupreina possesses the composition of evaporated bouillie bordelaise; used to make a bouillie, only gives imperfect results.

Occidine.—Mixture of blue vitriol (7·5 per cent), green vitriol, sulphur, naphthalene, and carbonate of lime.

Powders having the Composition of Bouillie Bordelaise, Burgundy Bouillie, and Eau Celeste, intended to be diluted with Water and used exclusively as Bouillie :—

Parasiticine.—Mixture of blue vitriol 57 per cent, carbonate, and bicarbonate of soda.

Antimildioidium.—Mixture of blue vitriol 39 per cent, and carbonate of soda.

Poudre Crochepeyre.—Mixture of blue vitriol 53 per cent, and bicarbonate of soda.

Gelatinous Cupric Hydrocarbonate.—Mixture of blue vitriol 32 per cent, with carbonate and bicarbonate of soda.

Bouillie d'Azur.—Mixture of blue vitriol 48 per cent, and of bicarbonate of soda.

Poudre Eclair.—Mixture of blue vitriol 30 per cent, acetate of soda, lime, and acetic acid.

Fostitebrühe.—Mixture of blue vitriol 50 per cent, carbonate of soda and lime, tinted with aniline blue.

Krystallazurin.—Ammoniacal copper sulphate (70 per cent of blue vitriol).

Kupferpreparat Gmund.—Emulsion of ammoniacal sulphate of copper (blue vitriol 20 per cent) in water, and 11 per cent of oil.

Kupfer soda, etc., etc.

Use against Smut (*Ustilagineæ*).—It follows from the mode of propagation of rust diseases that only the disinfection of the corn-seed and the dung can prevent the cryptogamic diseases of grain crops; that no spraying can lessen, contend with, or prevent. Amongst chemicals used to disinfect seed-corn blue vitriol is one of the most powerful and the one in current use. The only drawback lies in the very decided sensitiveness of the grain to solutions of this poison. Different [chemical] agents have not the same effect on the germination of the seed. Chlorine water and lime water exert no injurious action; mineral acids retard germination without lessening the germinative capacity, whilst metallic salts, such as green vitriol, blue vitriol, sugar of lead, and others, are poisonous in small doses; a germination of 100 per cent is only obtained by observing certain limits of concentration, special to each salt. In disinfection with blue vitriol a 0·5 per cent solution must not be exceeded. More concentrated solutions yield the following:—

TABLE XXVII.—*Showing the Effect of Steeping Seed-Corn in Solutions of Blue Vitriol of Different Strengths for Different Periods of Time.*

Strength Per Cent.	*Time of Action.*	*Loss of Grains Per Cent.*	*Strength Per Cent.*	*Time of Action.*	*Loss of Grains Per Cent.*
1	15 minutes	10	2	1 hour	46
2	15 ,,	14	2	2 ,,	54
2	39 ,,	28	2	3 ,,	59

The *strength* of the solution of blue vitriol and the *duration* of the steeping ought to be such that the blue vitriol *cannot enter* into the interior of the grain, but is confined to the disinfection of its exterior surface. As soon as the poisonous salt penetrates into the seed symptoms of poisoning are to be seen in the future plant. With solutions of different strength the following result was obtained:—

TABLE XXVIII.—*Showing the Effect on Height of Plant of Steeping Seed-Corn in Solutions of Blue Vitriol of Various Strengths.*

Strength Per Cent.	*Time of Steeping.*	*Height of the Plant.*	*Appearance after One Month.*
Blank	—	8-12 inches	Normal
0·5	2 hours	10-12 ,,	
1-2	2 ,,	8-10 ,,	Dark Colour
3-5	2 ,,	8 ,,	
10	2 ,,	6 ,,	

The greater the number of deep wounds sustained by the grain in threshing the more sensitive it is. When the grain is wounded nothing prevents the penetration of the copper solutions into the interior of the grain, and the embryo may be killed by a short immersion in a bath of blue vitriol. Ivans and Welter have made categoric experiments in this direction with grain wounded for the purpose.

TABLE XXIX.—*Showing Effect on Germination of Steeping Injured Grain in Water and in Solutions of Blue Vitriol.*

Nature of Injury to Grains.		*Immersion in*	*Germination.*
$\frac{1}{3}$ cut from side opposite embryo	Check	Water	90
	Treated	2 per cent solution of blue vitriol	44
Epiderm of embryo slightly damaged	Check	Water	40
	Treated	2 per cent solution of blue vitriol	*Nil*

The unwounded test samples were not injured by steeping from one to two hours in a 0·5 per cent blue vitriol solution, and even a 1 per cent solution when the action of the blue vitriol was stopped by a bath of milk of lime. Now it is a well-known fact that the threshing of grain in the threshing-mill damages about 30 per cent, whereas hand threshing [with the flail] does much less damage. This 30 per cent is generally killed by steeping in a solution of blue vitriol, so that it is necessary to use, in general, 30 per cent more seed to sow the fields when such corn-seed, disinfected by blue vitriol, is used. After a profound examination of the subject the greatest authorities, Deherain, Grandeau, Vilmorin, Sorauer, Loverdo, Brefeld, and others, agree on the superiority of the blue vitriol method, used rationally, over other methods of disinfection; it alone possesses the property of still acting after the sowing of the seed-corn within a certain radius of the latter. It protects them during the period the plant is vulnerable from the germs found in the soil, or which have been brought on to the land with the dung. From that point of view blue vitriol is superior to hot water, sodium sulphide, sodium sulphate, the disinfectant property of which is, however, analogous and the efficiency incontestable. However, blue vitriol, so as not to injure grain, must be used in a rational manner; the steeping should be as short as possible, and its action stopped at the right moment by converting it into an inert and insoluble derivative as soon as it has played its rôle of disinfectant. The methods recommended by Benedikt Prevost, in 1807, were not much altered by a deeper examination of the subject by Mathieu de Dombasle. By describing a practical method of disinfection the latter, however, largely helped to make this process general.

Here is his process: Dissolve 1 lb. of blue vitriol in hot water and make up the bulk to 20 gallons. Immerse the corn-seed into this bath in such a way that a layer of liquor, 4 inches in depth, remains above the seed. Stir several times and remove all the floating grains. After

twelve hours' steeping remove the seed and spread it on a board. It must be turned frequently. By this prolonged immersion and stirring the air adhering to the grain, often with tenacity, is gradually displaced, and the liquid touches their whole surface. Corn-seed so treated does not keep. Like all grain moistened and swollen by steeping it heats and spoils; blue vitriol then exerts a deadly action on the seed and kills a large quantity. It is thus absolutely necessary to sow the corn-seed as soon as possible, and as soon as it is dry again. If the operation be commenced at 4 o'clock in the morning it is finished in the evening; the next morning the corn-seed disinfected by the blue vitriol is bagged up in sacks, conveyed to the field, and sown as soon as possible. In spite of all precautions, loss in using this process is unavoidable, for the blue vitriol is concentrated, in drying, around the grains, where it acts as a concentrated solution. To remedy this drawback weaker solutions have been tried. If grains are only immersed for fifteen minutes in a 0·5 per cent solution they undergo no damage, and 99 per cent germinate, often even before the untreated grain; after steeping for three hours the grain does not germinate until three days after the untreated grain (experiment on oats, variety Scotch White Superior).

Bloymeyer advises a still shorter immersion, carried out thus: Run the corn-seed into a basket and dip that for one minute into a 1 per cent solution of blue vitriol. Drain and dry. If the time of steeping be considerably shortened, it is owing to the great concentration of the bath of blue vitriol. Herzberg found that the temperature of the blue vitriol solutions played a very important rôle. Below 8° C. the blue vitriol bath is, so to speak, without action on the spores of *Ustilago* (smut), whilst a solution at 24°-26° C., even if it only contain 0·1 per cent of blue vitriol, kills them instantly. This is explained by the fact that the spores are very resistant, but that the sporidia are very sensitive. By inducing their formation by a high temperature, the above result is obtained! Herzberg, therefore, recommends steeping for twenty-five hours in a 0·1 per cent solution at 25° C. The spores of *Tilletia* (bunt) do not behave similarly. They rather appear to be more sensitive to cold solutions; the most favourable temperature is from 6°-8° C. At that temperature a solution of 0·0004 per cent prevents their future evolution. This fact was pointed out by Prevost as far back as 1807, who gave $6\frac{1}{4}$° and $7\frac{1}{2}$° C. as the extreme temperatures to which these spores are most sensitive; at the ordinary temperature the immersion ought to last half an hour in a 0·05 per cent solution; at a higher temperature these solutions, therefore, have no action. Wheat, therefore, infected with germs of *Tilletia* (bunt) ought to be disinfected, according to Prevost and Herzberg, at a low temperature, whilst barley and oat seed infected with *Ustilago* (smut) should be disinfected between 24° and 26° C. Treatment by blue vitriol alone is abandoned now, because it is too often deadly. An injurious action has been found on grain after steeping one hour in a 0·1 per cent solution. The growth of the radicles is often affected to such a point that they do not form although the plumule may be long enough. When the radicle emerges its point is brown, and remains

sickly for some time. To avoid this annoying action of blue vitriol, produced after steeping (an action which is always dangerous because the adherent liquid becomes concentrated), a second steeping must be given, capable of removing this secondary action from the blue vitriol. Kuhn was the first to wash the disinfected grain and immerse it in a 6 per cent milk of lime. This method, which suppresses all the drawbacks of blue vitriol, has met with a wide response. It is in common use in Germany. Steglich places the corn-seed in a basket, dips it into the blue vitriol solution, takes it out and at once dips it into a solution of carbonate of soda. The copper carbonate which forms an insoluble layer round the grain is without any injurious action on it, but it is a very effectual protection against infection, which may occur after sowing. Hollrung altered this method; he steeps the grain in a vat containing only a 0·3 per cent solution of blue vitriol. After stirring the grain for four hours he takes it out and washes it for thirty minutes in a 0·4 per cent solution of milk of lime. The seeds are then spread on the floor in a thin layer and frequently turned. Each operation should be done in warm weather. In spite of all experiments on steeping, on the concentration of solutions, and on the temperature, Kuhn's process is used in actual practice, the steeping in a blue vitriol bath being followed by a passage through milk of lime. The dangers of too strong solutions being thus much diminished reversion was made to solutions of 0·5-1 per cent used in immersions of short duration. This operation, always long with dilute solutions, is thus greatly shortened. The following method most used in France was recommended by Deherain and Loverdo and popularized by the Minister of Agriculture. Dissolve 50-100 grammes (772-1543 grains) of blue vitriol in 10 litres (2·2 gallons) of water[1] and dissolve this in a vat containing 1 hectolitre ($2\frac{3}{4}$ bushels) of corn-seed, then add water until the grain is covered with a layer of liquid 4 inches deep. Stir the mixture. Remove the seed which float, then drain the remainder in a basket. After an hour dip the grain into fresh water, and dust with slaked lime (chaux fusée). To prevent any delay in germination Bernard advises a steep of the following composition: 50 grammes of blue vitriol (772 grains), 300 grammes of nitrate of soda (4632 grains), and 300 grammes of superphosphate (4632 grains) in 10 litres of water. After a short immersion in this steep the grain is pralined with ashes or slag. Seed-corn so treated has always shown a certain advance in its growth, and given higher yields because the plant finds after brairding a zone rich in nutritive substances. An analogous result is obtained by the repeated spraying of wheat in a heap. When all the grain is well impregnated with blue vitriol the heap is dusted with slaked lime. This method has the advantage over immersion of precipitating around the grain a strong layer of hydrated oxide of copper, which adheres very well to the surface and prevents ulterior infection by contaminated dung, but this process requires much handling for it requires continual shovelling.

[1] That is to say, at the rate of 5 lb. to 10 lb. of blue vitriol in 100 gallons of water, and of this solution use 1 gallon for every bushel of seed-corn.—Tr.

In spite of the perfection of the processes in use, even if there be no doubt of the superiority of this treatment over others, with the same end in view, loss of grain is inevitable, and it is necessary to increase from 20-30 per cent the amount of seed sown to prevent too thin sowing, although in practice there is only one treatment for all the cereals.

Barley.—Hordeum vulgare is infested by *Ustilago hordei*, Bref. and *Hordeum distichum* by *Ustilago Jensenii*, Rost.

TABLE XXX.—*Showing Effect on Germination of Seed Barley of Steeping in Solutions of Blue Vitriol of Various Strengths.*

Grain.	*Duration of Steep.*	*Strength of Steep Per Cent.*	*Germination of Grain Per Cent.*
Treated	24 hours	0·5	88
,,	,,	1	64
,,	,,	2	48
,,	,,	5	35
Check	—	—	98

TABLE XXXI.—*Showing Delay in Germination by Kuhn's Treatment.*

Soil.	*Grain.*	*Germination Per Cent.*			
		3rd Day.	*7th Day.*	*14th Day.*	*26th Day.*
Sand	Untreated	60⅓	95	—	—
,,	Treated	27⅓	97⅓	—	—
Soil	Untreated	—	—	45·7	86·7
,,	Treated	—	—	60·4	89·0

TABLE XXXII.—*Showing Effect of Blue Vitriol Pickle on Crop of Barley.*

Grain.	*Number of Ears.*	*Rust.*	*Weight of Grain. Grammes.*	*Weight of Straw. Grammes.*
Untreated	173	4	104·5	185·5
Treated	243·7	—	161·9	184·2

These experiments were made by Hollrung in using Kuhn's method of disinfection, 0·5 per cent blue vitriol and 6 per cent of milk of lime.

Oats.—Avenæ sativa is infested with *Ustilago Avenæ*, Rost.; *Avenæ elatior* is infested with *Ustilago perennans*, Rost.

TABLE XXXIII.—*Showing the Sensitiveness of Seed Oats to Blue Vitriol Pickle* (Gaillot).

Grains.	*Duration of Steep.*	*Strength of the Steep, Per Cent.*	*Germination of the Grain, Per Cent.*
Treated	24 hours	0·5	45
,,	24 ,,	1·0	20
,,	24 ,,	2·0	10
,,	24 ,,	5·0	0
,,	6 ,,	0·5	98
,,	30 minutes	1-2	98
Untreated	—	—	98

TABLE XXXIV.—*Showing the Delay in Germination by Blue Vitriol Pickling of Seed Oats* (Kuhn's method).

Soil.	*Grains.*	*Germination, Per Cent.*			
		4th Day.	*7th Day.*	*14th Day.*	*26th Day.*
Sand	Untreated	76⅓	93⅔	—	—
,,	Treated	43	94⅓	—	—
Soil	Untreated	—	—	51⅓	93⅓
,,	Treated	—	—	54⅔	88⅔

TABLE XXXV.—*Showing Effect of Kuhn's Blue Vitriol Pickling of Seed Oats on the Oat Crop* (Hollrung).

100 *Grains of Seed Oats.*	*Number of Ears.*	*Rust.*	*Weight of Grain in Grammes.*	*Weight of Straw in Grammes.*
Untreated	89⅔	5	107·7	157·1
Treated	77⅓	—	[illegible]0·5	205·8

Disinfection by Hollrung's method does not cause this diminution in the crop so perceptible in Kuhn's method.

Wheat.—*Triticum sativum* is invaded by *Ustilago Tritici*, Jensen (smut of wheat); *Tilletia caries*, Tul.; *Tilletia levis*, Kuhn (stinking smut bunt of wheat).—It is particularly on this fungus that Prevost tested the action of blue vitriol. By disinfecting "spotted" grain, that is to say, covered with spores of *Tilletia* (bunt), he obtained: Spotted non-treated grain, 486 per 1000 of rusted ears; spotted treated grain, 8 per 1000 of rusted ears, after steeping half an hour in a 1·2 per cent solution. Whilst blue vitriol used alone greatly reduces the germinative capacity of the barley, this treatment of Kuhn has not that drawback. Grain treated with 0·5 per cent solution of blue vitriol, however, does not show it if sown immediately (Grassmann).

TABLE XXXVI.—*Showing Reduction in Germinative Capacity by Delay in Sowing after Pickling with Blue Vitriol.*

Grain.	*Loss Per Cent in Germinative Capacity.*	*Total Germination, Per Cent.*
Untreated grain	95·75	98·6
Treated grain sown 1st day after disinfection	93·5	97·5
,, ,, 2nd ,, ,,	91·0	97·25
,, ,, 3rd ,, ,,	86·25	95·25
,, ,, 4th ,, ,,	81·25	95·75
,, ,, 10th ,, ,,	66·6	95·75

Owing to the similarity between the smut diseases of different plants, the methods found efficacious for smut of cereals may be employed in all cases.

Ustilago Panici-miliacei, Wint. (smut of millet).—The treatment of the grain by Kuhn's method, one hour's steeping in a blue vitriol solution of 0·5 per cent, followed by a 6 per cent milk of lime, prevents the infection of the young plant (plantule) by spores adherent to the seed. The same delay in germination was observed by Aderhold, who also found that 86 per cent of the seeds treated germinated, showing 0·4 per cent of rust against 90 per cent of the untreated seed with 7·45 per cent of rust. It is an excellent palliative, but it is better still to roast the spores by letting them fall through a twig broom held 1 metre above a very light straw fire.

Ustilago Maydis, Corda (smut of maize) cannot be avoided as surely as all the other rusts, because the spores of this fungus are of themselves able to penetrate into the adult plant through the newly formed leaf. In spite of this peculiarity blue vitriol is used with success, but it does not prevent future infection of the plant.

Urocystis Cepulæ, Frost (smut of the onion).—Although the disease may be suppressed by rejecting all rusty stocks on transplanti g, Mohr points out the good effect of spraying with a 3 per cent solution of blue vitriol.

Puccinia (rusts).—Three different species are found on grain crops: *Puccinia graminis*, Pers. (common or linear rust); *Puccinia Rubigo-vera*, Wint. (spotted mildew); *Puccinia coronata*, Cord. (rust of oats).—The development of rust differs totally from the method of propagation of smut and bunt. It is impossible to prevent rust of corn in the same way and at the same time as smut diseases by simple disinfection of the seed-corn. Their methods of multiplication are so varied that it is, so to speak, impossible to create an obstacle to the propagation of these diseases by chemical means so as to hope for a radical effect, curative or preventive, by the means which render such excellent service in combating other diseases. The means of action are very limited, and direct attack is impossible. It is only from an instructive point of view that the results obtained by spraying with blue vitriol preparations are given. Wuthrich has shown that the

uredospores, though much less resistant than the spores of most fungi, are yet destroyed by a 0·124 per cent solution of blue vitriol; their sensitiveness to this salt begins at the dose of 0·00124; at 0·0124 per cent germination is prevented. Hitchcock and Carleton found a 0·1 per cent solution prevented their germination without killing the spores. H. de Vilmorin and F. Douillet found that plants of white March Chiddam wheat, treated several times with blue vitriol sprays and afterwards conveyed close to mildewed wheat, were not attacked, whilst in the same conditions untreated plants were invaded. But this treatment, difficult even when the wheat is in the blade, becomes impracticable when it is in the ear. It is owing to this difficulty that this process has miscarried, although it has been found efficient in experiments on the large scale in Australia, and by Leon Noiret in the Côte d'Or. The dose required to kill uredospores is much greater than to destroy the zoospores of mildew of the vine, and it is surprising that spraying has such perfect results. In our opinion, blue vitriol would act in this case more especially as a stimulant, producing more active and vigorous growth, enabling the plant to oppose a greater resistance to invasion by this fungus, and thus to acquire a sort of immunity.

Helminthosporium gramineum, Eriks. (browning of barley).—Kolpaon Raon insists that Kuhn's process is an excellent means of preventing this disease.

Claviceps purpurea (ergot).—The conidia of this fungus do not develop in a solution of blue vitriol of 0·0124 per cent.

Dematophora necatrix (root rot of the vine).—Dufour recommends blue vitriol to prevent this disease. When the roots are completely invaded by the mycelium the plant is condemned, and ought to be destroyed, the more so as the organs of propagation, the conidiophores, charged with conidia, appear to develop, especially after the death of the tree. By tearing up the tree and carefully exterminating the débris of the roots and the ropes, the propagation of the disease is prevented. To destroy the spores, or the mycelium, of which the soil may retain a fraction, the latter is watered with a 3 per cent solution of blue vitriol. Before planting new vines 1-2 litres of this same solution is poured into the holes. Within a radius of 2-3 rows the stocks already attacked or not are stripped in the spring and freely watered with this solution; 100-150 grammes of blue vitriol in powder may likewise be spread per stock. The result is not always complete and visible the first year, and it is sometimes necessary to repeat this treatment two years running; the results obtained in these conditions are, however, very positive.

Guignardia Bidwellia, Viala et Ravaz (black rot of the vine).—From the first appearance of this disease, when it was found that it did not appear at first on the fruit but only the leaves, which then became hotbeds of infection for the grapes, attempts were made to stop its evolution by repeated sprayings of blue vitriol. The experiments made at Ganges were not very satisfactory, whilst bouillie bordelaise later on gave the most perfect results. Rathey and Havelka have proved that the spores are killed after thirty hours' steeping in a

blue vitriol solution of 0·5 per cent, and they recommend the disinfection of the buds of the vine against black rot by total or partial immersion in a 1 per cent solution for one hour. Their experiments succeeded perfectly, and proved also that the steeping of the buds for an hour in 1 per cent, 5 per cent, and even 10 per cent solutions of blue vitriol, did not lower their vitality; the lower section seems as if it could no longer form a cushion to remedy this drawback: it suffices to cut ¾ of an inch below the buds before transplanting them.

Gloeosporium ampelophagum, Sacc. (grape rot).—Sorauer recommends blue vitriol in place of green vitriol to combat this fungus in winter. Instead of coating the stock with a 50 per cent solution of green vitriol a 20 per cent solution of blue vitriol is used. This practice is excellent, but more costly than Slavinsky's.

Gloeosporium nervisequum, Sacc. (disease of the leaves of the plane-tree).—Nobele recommends, to prevent this disease, to spray with a 3 per cent solution of blue vitriol in the month of April and in the month of May before the tree is in leaf.

Fusicladium pirinum, Fuckel (pear scab); *Fusicladium dentriticum*, Fuckel (apple scab).—These diseases may be combated by spraying with blue vitriol solutions. By judicious spraying at the right moment the conidia formed on the cushion of the conidiophores of the leaf are destroyed, and prevented from planting themselves on the fruits. Oliver found that the spores were destroyed by blue vitriol. Used on large scale in 0·5 per cent solution by Goff, he greatly diminished these diseases. Mohr recommends a 3 per cent solution for the same purpose. These sprayings should be done before spring, in the month of April. Blue vitriol has not such a radical action as bouillie bordelaise. The latter may, if used before the expansion of the buds, completely prevent these diseases.

Morthiera Mespili, Fuckel; *Entomosporium maculatum*, Lev. (leaf scald).—This disease of the leaves of the pear may be prevented, according to Mohr, by spraying with a 3 per cent solution of blue vitriol before the formation of the leaf in April and May.

Disease of the Poppy (œillet).—Mangin advises to prevent this disease to steep the buds in a 0·1-2 per cent solution of blue vitriol before transplanting.

Beet Diseases.—To prevent these diseases, transmitted by spores infecting the seed, disinfect the seed with blue vitriol, which gives good results against—

Pleospora putrefaciens, Franck (rot of the heart of the beet) and *Phoma tabifica*, Prill. et Dell. (*Phoma Betæ*, Franck), (disease of the leaf-stalk of the beet).—Carlson advises washing the seed in a 1-2 per cent solution of blue vitriol. Linhart advises steeping for twenty-four hours in a 2 per cent solution; although this diminishes the germination of the seed a little, yet Franck recommends it. It also removes the larvæ of *Agriotes lineatus*, *Hypomyces magnus* (mole disease of the mushroom). It requires three to seven days' steeping in a 2 per cent blue vitriol solution to kill the spores. This disease is not circumscribed by this salt.

Black Disease of the Clematis.—To prevent this disease produced

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by a slug, copious spraying with solutions of blue vitriol every fortnight before transplanting have a good effect.

Use of Blue Vitriol against Worms and Snails.—Snails and slugs are as sensitive to blue vitriol as to green vitriol. If they pass over a surface sprayed with blue vitriol they soon die. The hatred of snails for blue vitriol is such that to remove them it suffices to stretch a cord, 1½ inches wide, steeped for twenty-four hours in a 10 per cent solution. This cord ought to touch the soil; it forms an insurmountable barrier. This method is practised in Italy. Bignon has also observed that the vitriolizing of ropes and trellises remove slugs.

CHAPTER XIV.

COPPER HYDRATE—BOUILLIE BORDELAISE—BOUILLIE BOURGUIGNONNE.

91. Copper Hydrate (Bouillie Bordelaise).—Preparation.—By precipitating a soluble salt of copper, by caustic alkali, or by milk of lime.

$$\underset{\text{Copper sulphate.}}{CuSO_4} + \underset{\text{Sodic hydrate.}}{2NaOH} = \underset{\text{Cupric hydrate.}}{Cu(OH)_2} + \underset{\text{Sodic sulphate.}}{Na_2SO_4}$$

$$\underset{\text{Copper sulphate.}}{CuSO_4} + \underset{\text{Calcium hydrate.}}{Ca(OH)_2} = \underset{\text{Copper hydrate.}}{Cu(OH_2)} + \underset{\text{Calcium sulphate.}}{CaSO_4}$$

The bouillie bordelaise is prepared by the second reaction; it is a mixture of hydrated oxide of copper and sulphate of lime, and generally contains an excess of lime. Its composition and its concentration vary much.

Preparation of a Normal Bouillie Bordelaise.—A solution of blue vitriol is prepared on the one hand, and on the other hand a milk of lime carefully rubbed up with water.

1. *Blue Vitriol.*—This salt should be as pure as possible. It should be dissolved in wooden, copper, glass, or stoneware vessels; those of tin and iron should be avoided, as these metals decompose blue vitriol. To facilitate solution of blue vitriol it is placed in a basket or pocket of wire gauze, in a vessel filled with rain water, so that it dips into it completely, but as near the surface of the liquid as possible. Solution is complete in twelve hours. If pressed for time blue vitriol may be dissolved in a little warm water and this solution run into the receiver containing the remainder of the water required to make the bouillie. It is necessary to use a *cold* solution of blue vitriol in making the mixture, for with hot solutions there would be formed, along with the granular hydrated oxide of copper, some inert black oxide of copper.

2. *Milk of Lime.*—The lime should be fat lime in lump. This quicklime is slaked by adding water gradually. As soon as it is slaked it is beaten up in cold water to form milk of lime. This milk of lime is passed through a fine sieve, to separate the impurities present in all limes. To obtain a fine, gelatinous, homogeneous precipitate, having a maximum adherence to the leaves it is advisable to mix these two liquids as follows: The milk of lime is run slowly, in a fine stream, into a cold solution of blue vitriol, stirring constantly, or better still, run the two solutions simultaneously and slowly into a third vessel,

stirring the latter energetically. Theoretically 14 lb. of pure quicklime suffice to precipitate 62½ lb. of pure blue vitriol. Practically the amount of lime used is always greater, because the lime is never pure. The amount of lime varies, therefore, according to its purity, from 1-3 lb. of lime to 3 lb. of blue vitriol. The most advisable quantities to form an active bouillie are 10 lb. of blue vitriol in 50 gallons of water, and 3½-10 lb. of lime, dissolved in 50 gallons of water. The mixture formed by these two solutions is termed a 1 per cent solution.

Properties of Copper Hydrate.—Copper hydrate is a pale blue precipitate, which is more fine and gelatinous the lower the temperature at which it is precipitated. It is almost insoluble in water at all temperatures; it is converted in hot water into black copper oxide, CuO. It is, however, soluble in mineral and organic acids.

Properties of Bouillies Bordelaises.—A bouillie bordelaise, prepared in good condition, should have the following properties: *It should be neutral or slightly alkaline; it must never contain an excess of blue vitriol.* To ascertain its composition a little of the bouillie is filtered, or allowed to settle. The limpid liquid collected should not be tinted blue (which would point to unchanged blue vitriol), but should be absolutely colourless. It should give no reaction with litmus paper, nor an alkaline reaction with turmeric paper. Another and still better method of showing the presence of small quantities of undecomposed blue vitriol consists in placing a little bouillie bordelaise in a saucer and to pour on it a few drops of yellow prussiate. The presence of blue vitriol is revealed by a red coloration of the bouillie. A blade of a knife dipped in a bouillie, still containing blue vitriol, is covered with a deposit of metallic copper.

The bouillie must be tested and respond to the tests in the right way, otherwise it is unfit for all the purposes for which it is intended.

Too often the sprayings eventually burn the leaves and the young parts of the plant. They are due, with few exceptions, to faults in the composition of the bouillie. Traces of blue vitriol, not converted into cupric hydrate, suffice to cause these burns. As a preventive of cryptogamic diseases the bouillie must be as adherent as possible, so as to prolong its action on the surface of the vulnerable organs of the plant.

Adhesion depends on several factors: (1) The blue vitriol should be precipitated cold, as above described, by milk of lime. (2) The more pure (fatty) the lime, the more adherent the bouillie. (3) The more freshly prepared, the more adherent the bouillie. (4) The bouillie is the more adherent the more nearly neutral it is; that is, without an excess of lime. Although it is not injurious to vegetation, it is well to estimate exactly the quantity of lime to use in preparing the bouillie. Lime in excess has, moreover, the drawback of retarding the action of the bouillie bordelaise on the germs of cryptogamic fungi. Cupric hydrate as deposited on the leaf of a plant is, so to speak, insoluble, and thus inert towards the spores in contact with it. To become active it must be converted, in contact (1) with the air, into copper carbonate, soluble at the rate of 40 milligrammes in a litre of water containing carbonic acid; or (2) with carbonate of ammonia, or be dissolved by the juice

exuded on the surface of the leaves. Whichever of the two cases occurs, or both together, it will be seen that cupric hydrate mixed with a large excess of lime will not have such a rapid action as in the absence of lime, the latter having a great affinity for carbonic acid. It also neutralizes organic acids, and in many cases, as the action of the bouillie bordelaise cannot be retarded, to stop infection an excess of lime should be avoided. An excess of lime delays the action of bouillie bordelaise one to ten days, according to the amount of lime used. Bouillie bordelaise, when well prepared, combines all the properties required in an anticryptogamic bouillie, and all the substances added to increase its toxic action on spores or adherence to the leaves are useless if it be conscientiously prepared and used immediately afterwards. To popularize its use the trade has prepared powders, having exactly the composition of a normal bouillie, which only require mixing with water to produce a bouillie bordelaise. The greater number of these powders yield bad bouillies; they may undergo decompositions, rendering them unfit for the preparation of a proper bouillie, and yield heterogeneous bouillies, in which undissolved blue vitriol is plastered up with a layer of sulphate of lime. Not only does it become difficult to use them with the spraying machine, but they have all the defects of badly made bouillies. If applied by the bellows the same thing occurs on the leaf, the chemical reaction is incomplete, the blue vitriol acts as such and causes burns. Nothing, therefore, can replace a bouillie made on the spot by one's self, with the precautions indicated above, and no similar preparation can be either so adherent or so efficient.

Action of Cupric Hydrate on Plants.—Insoluble copper salts appear to be absorbed to as great an extent by the roots as by the aerial organs of the plant, and cause poisoning. If the doses absorbed are infinitesimal no poisoning occurs. The copper salts then exert a salutary stimulating effect. It was thus essential to find a salt of copper which in contact with plants was only absorbed in infinitesimal doses, simultaneously stimulating the growth of the plant and destroying cryptogamic disease. It was found that cupric hydrate fulfilled these conditions best and that bouillie bordelaise could practically fill that rôle. The cupric hydrate deposit formed on the leaves is very adherent, insoluble in water, and barely soluble in water containing dissolved carbonic acid or carbonate of ammonia. It lets the plant absorb it in infinitesimally small doses, which might escape detection in analysis, but which none the less exist since their presence in the leaf renders it so far immune to cryptogamic diseases, and especially vigorous analogous to the condition realized by spraying the soil with blue vitriol. Leaves of the potato plant treated with bouillie bordelaise become thicker and more vigorous, the chlorophyll increases, assimilation is more active, and the starch content of the tubers greater (Frank and Kruger). Galloway got the same results with fruit trees. Young plants sprayed three to four times a year showed much more rapid growth, and preserved their leaves into the winter. It is very evident since this cupric treatment gives to the leaf a great assimilative force, and that it prolongs this into the winter, the young tree will have grown more rapidly

than trees which prematurely shed their leaves by degeneration induced by parasites. Numerous comparative trials have shown in an irrefutable manner, that young fruit trees in the nursery, treated with four to seven sprayings with a 2 per cent bouillie bordelaise, show an increased height, and yield crops largely compensating for the cost of this treatment. In nurseries young pears treated three years in succession attained a height of 5 feet to over 7 feet, and had a diameter of $7\frac{1}{2}$ inches, whilst untreated pear-trees of the same age, placed in the same conditions, only reached 2-3 feet in height and only $2\frac{1}{2}$-$3\frac{1}{2}$ inches in diameter. If the market value of young pear and cherry trees, treated together for three years, be compared with similar untreated trees, there is a gain after deduction of all the cost of treatment of 52 shillings per 1000 trees. With young pear-trees the experiments were not so decisive, as their leaves are often sensitive to bouillie bordelaise. The same observations have been made as regards the vine. To obtain a richer growth large doses of copper are not necessary. It is now believed that 0·25 per cent, and even 0·1 per cent, do the same good as 1 per cent bouillies. Bessler, by one spraying of bouillie bordelaise on haricots when tilling the ground, followed by one spraying of the young plant, obtained a 50 per cent better crop than on untreated plants. It is only the stimulating and preventive treatment which gives this result.

We must not wait until plants show signs of cryptogamic diseases before treating them, but prevent such by destroying the germs. Some plants, however, do not stand the deposition of hydrated oxide of copper on their leaves without injury, because, owing to the exceptional nature of the foliageous tissue, it is absorbed in too great quantity, and then acts like blue vitriol. The plants which behave thus are apple-trees, peach-trees (Sturgis, Müller, Thiel), and some varieties of rose bushes. On these trees the treatment is followed by the fall of all the leaves reached by the bouillie bordelaise, or at least by burns which cause holes in the leaves. Müller and other observers found that these burns especially occur when the plant is exposed to the sun, and that plants in the shade do not show these injuries. Amongst apple-trees the most sensitive are Canada Cordon, Bellefleur jaune, Ribstone pippin, Danziger Kantapfel. On these species the leaves appear riddled with holes after treatment. Trials, to see if lime contributed to the injurious action of the bouillie bordelaise, have shown the contrary. Whilst a 4 per cent milk of lime has no injurious action on bouillie bordelaise, a 0·5 per cent solution of blue vitriol and a 1 per cent milk of lime burnt the leaves as much, and even more, than a bouillie with 4 per cent of lime and ·05 per cent of blue vitriol. The peach-tree—the most sensitive to bouillie bordelaise—behaves towards it as towards pure blue vitriol. The treatment is followed in most cases by the fall of the leaf; but after this treatment the peach, nevertheless, shows the same recrudescence in its vitality as soon as the new leaves come forth, so that in the end this treatment is as salutary as for other trees. The action of cupric hydrate is thus analogous to that of green vitriol; in a general way this salt increases the chlorophyll, and consequently the assimilation; it thus prolongs the

vitality of the deciduous organs of the plant. Green vitriol, being present in commercial blue vitriol to at least 2 per cent as an impurity, it was imagined, first in America, then in Germany, that the strengthening effect produced by the bouillie was only due to this green vitriol, for which reason Aderhold advised the use of a bouillie bordelaise of the following composition: Blue vitriol 1·9 per cent, green vitriol 0·1 per cent, lime 2 per cent. Guocdenovic, who examined these bouillies, found that they had not any greater stimulating action than an ordinary bouillie of 2 per cent blue vitriol and 2 per cent lime. The dose of green vitriol, required to produce an analogous physiological effect to that produced by spraying with bouillie bordelaise is 0·5 per cent. The plant must also come in contact with the soluble salt, the green vitriol, the hydrated oxide of iron deposited on the leaves having produced no result, except as a 3 per cent bouillie. A bouillie containing 0·1 per cent of green vitriol in an insoluble form, cannot therefore act on the plant and strengthen the action of the bouillie bordelaise, far less the impurities, which only bring 0·04 per cent of hydrated oxide of iron in contact with the leaves. It must therefore be admitted that blue vitriol acts in the same way as green vitriol, but it is about ten times more active in much smaller doses. Then comes the problem of the absorption of the copper by the leaves when this product is deposited thereon in an insoluble form. Although the increase of the chlorophyll may be easily determined, although the action of the copper on the plant be undeniable, it is very difficult to find in the leaf, in consequence of this treatment, abnormal quantities of copper. It is thus owing to imperfections in our methods of analysis that it is generally believed that copper is not absorbed by the leaf. Sestini has, however, found more than normal amounts of copper in vitriolized vines. Analyses of this sort are very difficult and very delicate to make, for many reagents, even distilled water itself, may contain the infinitesimal doses of copper sought for in the plants. Nägeli, from experiments he made on the alga spirogyra, concluded that a plant which did not show any symptom of poisoning could not have absorbed copper, as the latter, absorbed by a cell, kills it, and since the favourable action of copper is undeniable, it must act at a distance. These conclusions raise hypothetical questions which we cannot discuss. It will be sufficient to point out some facts which plead in favour of absorption, and which show that the plant is perfectly capable of dissolving insoluble copper derivatives deposited on the surface of the leaves, and of absorbing them in minimum quantity. Barth was the first to express the opinion, so disputed by Droop and Wortmann, that cupric hydrate is dissolved by the exudations of the leaf. Clark has given considerable support to this hypothesis. Having observed that animal and vegetable substances were capable of dissolving cupric hydrate, an observation which Swingle had already made as regards the secretions of certain fungi, he concluded that certain organic compounds contained in the juice of plants may dissolve cupric hydrate. To verify this hypothesis he wrought on the leaves of the peach-tree, which are the most ready to absorb copper. In fact, these leaves covered with

a layer of bouillie bordelaise, give up to the water lying on them for some time a quantity of dissolved copper capable of killing the spores of fungi. When there is dew on a leaf, two liquids, separated by a membrane, are present, the one is charged with soluble bodies, while the other is pure water. It follows that exosmosis of the leaf may occur towards the dew. The organic substances thus in contact with the deposit of cupric hydrate may dissolve not only the quantities required to kill the germs fallen on the leaves, but also those indispensable to the plant itself. Thus the dose of soluble copper collected in this way by Clark killed the spirogyra. The water thus contained more than 0·000001 per cent, an amount perfectly sufficient to stimulate the plant. From the deadly effect of blue vitriol on the cells of plants, and the difficulty with which this salt is absorbed, it does not necessarily follow that the insoluble salts deposited on the plant behave in the same way. Those which are insoluble and neutral would have no action on the plant, nor on the spores of fungi, if they were not rendered soluble and assimilable by conversion into a soluble organic salt, which may be absorbed by the leaf and destroy the spores on the surface of the organs of plants. The amounts of soluble copper salts required to stimulate the plant are so small, and those which suffice to preserve it from invasion, by injurious fungi, are so infinitesimal, that their presence in the organs of the plant which have been in contact with the copper cannot be chemically demonstrated ; but the principle of absorption cannot be denied, since the constant presence of copper in the ashes of the plants treated has been determined by analysis.

Action of the Bouillie Bordelaise on Fresh-water Algæ.—Green algæ behave towards copper like all green plants, but they are much more sensitive to its action, probably because in the experiments all the body of the plant dips into the poisonous solution. This plant is perfect for allowing the observer to follow progressively the action of blue vitriol on the living cell. Nägeli examined and determined the precise action of blue vitriol on spirogyra. It was desired to determine, likewise, how this alga behaves towards bouillie bordelaise. Rumm undertook this work and examined separately the action of the different ingredients composing bouillie bordelaise on the alga *Spirogyra longata.* Sulphate of lime had no action. Calcium hydrate is absorbed, beginning with a strength 1 in 3750 and then acts in an injurious manner. Cupric hydrate is not soluble enough in water to cede to it an amount of copper capable of preventing the growth of the alga. On the other hand, the contact of cupric hydrate with the alga kills it, owing to evident and visible absorption of copper. The chlorophyll bands are torn, the plasma contracted, and the colour of the contents browned. Rumm explains this fact by the secretions of the alga dissolving the cupric hydrate, and the soluble derivatives absorbed by it of a certain strength kill it. He observed, however, that this action was more dilatory the more lime the bouillie bordelaise contained. In presence of a large excess of lime the action became *nil.* The bouillie bordelaise acts therefore on algæ containing chlorophyll as on other green plants.

Action of Bouillie Bordelaise on Fungi.—Cupric hydrate is

not soluble enough in water to prevent the germination of the spores most sensitive to copper salts, even after prolonged treatment with them (Aderhold and Rumm). To understand the action of bouillie bordelaise, it is, however, necessary to admit that there is a partial solution of oxide in the water deposited on the plant owing to the contact of this oxide with the active organs of the latter. Clark, in examining the poisonous capacity of the most diverse derivatives of copper on fungi cultivated in a nutritive liquid, beet extract, observed that this liquid dissolved cupric hydrate. Examining afterwards other substances of vegetable origin, he found they had the same property. This led him to believe that hydrated oxide of copper insoluble in water is much less so in presence of special organic substances. Swingle had already shown that the secretions of certain fungi dissolve cupric hydrate. Clark found afterwards that extracts of *Psaliote campestris*, as well as infusions of different parasitic fungi, dissolve this oxide of copper in sufficient quantity to prevent the germination of their spores. The nature even of the fungi would thus contribute to dissolve the amount of cupric hydrate required to prevent the development of the spores. The rapidity with which the spores are destroyed depends on the thickness of the exospore. On the other hand, Sorauer believes that the spore is never killed by the presence of cupric hydrate in the drop of water in the midst of which it is developed, but that, on the other hand, this copper derivative, by weakening it, prevents the germination tube from penetrating into the nurse plant. Hence, spraying with bouillie bordelaise on a plant invaded by a fungus is never capable of destroying the mycelium of this fungus developed in the interior of the plant. It cannot even prevent the latter from fructifying normally, and spreading around it spores to propagate the disease. The sole object of spraying with bouillie bordelaise is to prevent the penetration of these spores into healthy unattacked plants or their organs. When spraying is done in the right conditions, the bouillie bordelaise covers all the vulnerable surface of the plant with a layer of cupric hydrate. This layer forms a fixed and adherent reserve of a poison of which an infinitesimal quantity dissolved by the juices of the leaf stops the normal evolution of the spore fallen on a drop of dew. At the same time the very small quantities which penetrate into the plant, impart to it greater vigour which enables it to become to a certain extent immune to the disease.

Use of Bouillie Bordelaise.—*History.*—It was found by a chance observation, that a mixture of lime and copper might be useful in the struggle against cryptogamic diseases. To prevent marauders from gathering the ripe grapes on vines along the roads it was customary, long before the appearance of mildew, in the different communes of Burgundy to spray the grapes with milk of lime, to which was added a little blue vitriol to blue it. They treated five to six stocks in the border in this way. Now, as far back as 1882 it was found that these borders were less subject to mildew than the rest of the vineyard, and when the disease assumed extensive and intensive proportions, as was the case in 1884, round about St. Julian, this border bespattered by milk of lime, blued by blue vitriol, appeared quite detached from the

rest by the verdure of the leaves, and by the perfect health of the grapes. Owing to experiments made by Millardet and Jouet, it was found that this fortunate action was to be attributed to the copper and not to its lime. This empirical remedy was thus recommended to combat mildew, under the name of bouillie bordelaise. In the beginning the bouillie bordelaise was much stronger than now. It consisted of 15 per cent of lime and 8 per cent of blue vitriol. This bouillie was spread on the vine by means of small heather brooms, for its consistency did not allow the use of a spraying machine. From year to year the dose of blue vitriol was diminished, and the lime, an excess of which was found useless, was reduced to the dose strictly necessary. In 1887 bouillie bordelaise consisted of 3 per cent of blue vitriol and 1 per cent of quicklime. Millardet and Gayon had already experimented at this time with weaker bouillies, with 2 per cent, and even 1 per cent of blue vitriol. As these bouillies produced the same effect, they regarded them as efficient and recommended several sprayings with a 1 per cent bouillie in preference to a single spraying with a 3 per cent bouillie of blue vitriol. These results were published in 1888, and spread the formula of the new bouillie over the whole world, where it was adopted as the normal bouillie. Owing to a great increase in the price of blue vitriol it was tried to reduce the amount of blue vitriol entering into the bouillie. Guocdenovic has shown that a 0·5 per cent bouillie suffices in all cases. Zweifler extended his experiments from 2 per cent to 0·1 per cent bouillie, and concluded that 0·5 per cent of blue vitriol was sufficient—an efficient bouillie against mildew. These proportions are used on the large scale and with great success in Italy and the Tyrol. Used at first exclusively against mildew it has been found that bouillie bordelaise is perfectly capable of combating a great number of other diseases.

Practical Spraying.—The less cupric hydrate in the bouillie the greater must be the number of sprayings. Repeated spraying against plant diseases is in general favourable, because only the organs of the plant reached are rendered invulnerable, so far as wind and rain have not removed the preservative layer of copper oxide. To preserve a plant for the whole year from disease, the growth of the spores of parasitic fungi must be stopped. As there is a continual growth of new leaves uncovered by bouillie bordelaise, several sprayings must be applied preferably during fructification of the fungi, and especially during the germination of their spores. To prevent plant disease by bouillie bordelaise it is necessary—

1. That the bouillie be made conscientiously according to the preceeding rules. Bouillie bordelaise is mostly used neutral. However; numerous experiments by Mader, Bain, Sturgis, and Aderhold have shown that in certain special cases it is better to use bouillies containing an excess of lime. Certain fruit trees, sensitive to neutral bouillie bordelaise as much as to pure blue vitriol, are so no longer when there is excess of lime. Against the cryptogamic diseases of the apple and peach trees, it is well to use 0·5 per cent of blue vitriol and 4 per cent of quicklime.

2. That the evolution of the disease to be fought against be

Fig. 8.—Eclair Sprayer.

Fig. 9.—Eclair Sprayer, No. 1.

Fig. 10.—Eclair Sprayer, No. 1 *bis*.

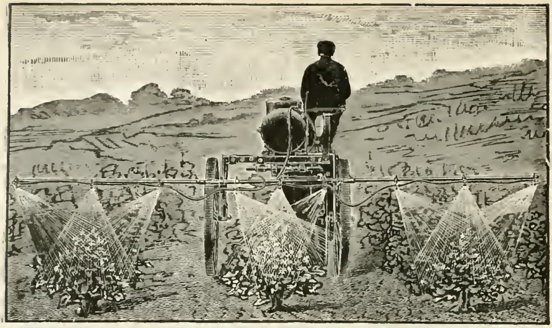

Fig. 11.—Eclair Sprayer Supra.

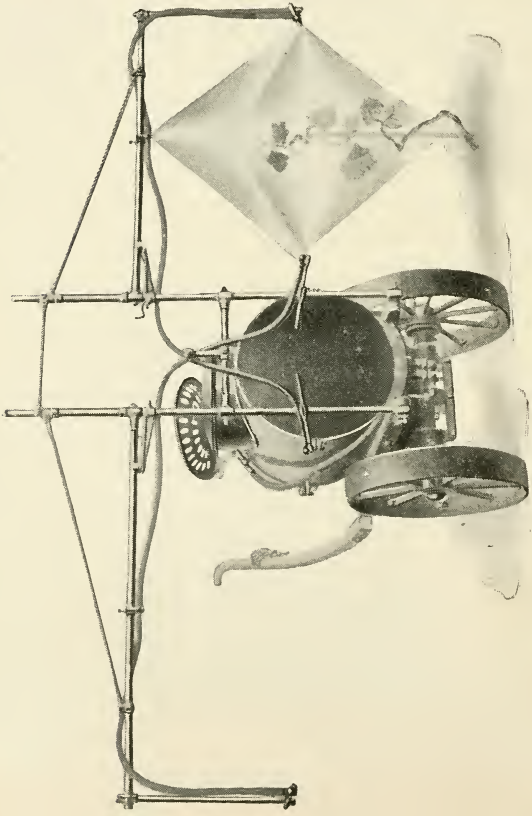

Fig. 12.—Vermorel's Spraying Machine, "Le Priam".

perfectly known, so as to be able to treat it at the moment of the dissemination of the disease, and prevent in time its establishment in the plant; a slight delay in the use of the remedy may lead to complete failure, for it is asserted by Prillieux that spraying after the penetration of the spores of the fungi into the interior of the tissue of the plant in no way prevent its normal evolution and fructification. If a great number of fungi may thus be combated by a neutral well-made bouillie, with 0·5-1·0 per cent of blue vitriol, the application of the remedy must vary with the method of propagation and evolution of the fungus. If these rules are observed bouillie bordelaise gives perfect results in all cases quoted farther on. Hence there is annexed to this treatise a brief sketch of the evolution and manner of life of the chief parasitic fungi, so that the amateur little versed in these questions may find both the remedy and the best time to use it.

Use against Mosses and Lichens.—Although cupric hydrate has not the solubility of blue vitriol its regular use on the trunks of trees helps to lessen these parasites and eventually cause them to disappear. Waite, Schoyen, Hume, and Leroux advise for this purpose a 3 per cent bouillie bordelaise applied on the trunks after cleaning with a scraper.

Use against Bacterian Diseases of Plants.—Amongst the ever-increasing number of plant diseases attributable to bacteria some may be combated with bouillie bordelaise.

Potato Scab.—Bolley, who discovered the cause of the scab, found that disinfection of the tubers with 2 per cent bouillie bordelaise was capable of preventing the growth of this disease. He got the following result:—

TABLE XXXVII.—*Showing Effect of 2 Per Cent Bouillie Bordelaise in Preventing Potato Scab.*

Tubers.	*Duration of Steep.*	*Sound Tubers, Per Cent.*
Untreated	—	1
Treated	½ hour	57
,,	3 hours	53

Longer steeping of the seed in bouillie bordelaise does not injure the seed if it has not sprouted.

Bacterian Disease of the Wild Quince-tree.—This disease known in America has been successfully treated with bouillie bordelaise.

Use against Parasitic Myxomycetes.—*Plasmodiophora californica*, Viala and Sauvageau (browning of the vine or the Californian disease).—This disease cannot be treated with bouillie bordelaise (Sorauer).

Use against Parasitic Fungi.—*Peronosporæ.*—The eighty known species, each more formidable than the other, have the same evolution

and the same method of dissemination. They may be treated with bouillie bordelaise.

Phytophthora infestans, De By. (potato disease).—To avoid the phytophthora sound tubers which do not bring the first germs into the field must be planted in the first instance, and secondly sprayed on the stems to prevent the propagation of the disease by plants accidentally attacked.

Treating the Tubers.—Beyond scrupulous sorting disinfection may be of great service. Of all the treatments recommended, that of bouillie bordelaise is the most energetic and the most certain. The tubers are steeped in a 2 per cent bouillie bordelaise; 10 gallons of bouillie suffice for 100 lb. of tubers. The duration of the steep is twenty-four hours, after which the tubers are steeped for twenty-four hours in pure water, then they are dried in the open air. The treatment should be carried out five to six weeks before planting. The disinfection has no objectionable effect on the germinative capacity of the tuber if the process be conducted as recommended by Frank. Godefroy found no alteration even after several days' steeping in the bouillie. Frank and Kruger found the treatment, on the contrary, favourable to the future evolution of the potato; it springs up quicker and yields a more vigorous plant and also a greater number of tubers in the ratio of 3 to 2. The good effects of the bouillie on the germinative capacity are not felt, except on condition that the tuber has no forward sprouts at the time of treatment, for the bouillie is very injurious to them. That is the reason why it is essential to disinfect potatoes sometime before planting them, when they have not yet sprouted.

Treatment of the Stems.—So long as treatment by the bouillie bordelaise was limited to the aerial part of the plant the results were not always favourable, especially as regards the yield in tubers, and opinions as to the efficiency of the treatment were divided. In fact it will be seen that where the phytophthora has deeply invaded the tissue of the tubers a treatment of the stems with bouillie bordelaise can prevent the evolution underground of the disease, and that failure is inevitable in such conditions. If all underground evolution is, on the other hand, prevented by a rational treatment of the seed potatoes, the effects of the aerial treatment will not fail to give satisfaction. It is not, therefore, surprising that certain experimenters have obtained, in some cases, a considerably diminished yield. Lieber found 20 per cent and Brunner 47·5 per cent, and that this treatment, which was first tried by Jouet in 1885, did not become general so rapidly as that for the mildew of the vine. However, Fasquelle's trials in 1886, Prillieux's in 1888, and Girard's in 1890, showed that a scientific application of bouillie bordelaise killed the phytophthora without injuring the plant. The diminution in the number of tubers, and in the starch which they contain, seems due to the poisoning of the leaves by imperfect bouillie, inducing a degeneration of the leaves, which renders them less fit for assimilation (Sorauer). The bouillies used at first contained too much copper and caused burns. Sempotovsky threw light on this point by showing that the weaker the bouillie the more active it is.

TABLE XXXVIII.—*Showing Effect of Bouillie Bordelaise of Various Strengths on Weight and Starch Content of Potato Crop and Per Cent of Diseased Potatoes.*

Diseased Plants.	*Bouillie Bordelaise, Strength, Per Cent.*	*Weight of Crop Per Acre in Tons Metric.*	*Starch, Per Cent.*	*Diseased Tubers, Per Cent.*
Untreated	—	10·28	19·1	6
Treated	6	11·2	18·0	2·8
Untreated	—	10·48	19·6	5·2
Treated	8	8·52	18·1	3
Untreated	—	10·4	19	4·5
Two treatments	One 4, other 6	8·84	19·4	2
Untreated	—	9·9	18·01 (3928 lb.)	15·5
Treated	2	9·96	19·28 (4405)	1·5

The number of sprayings in the year thus has a great effect on the efficiency of the treatment. Thienpont showed that the effects obtained by several sprayings are always superior to those obtained by a single spraying. Laplæ, in this connexion, got the following results :—

TABLE XXXIX.—*Showing Beneficial Effect of Repeated Spraying with Copper Bouillies on Potatoes.*

Diseased plants	untreated	10·44	metric tons per acre.
,,	1 spraying	10·88	,, ,,
,,	2 sprayings	11·94	,, ,,
,,	3 sprayings	12·88	,, ,,

As to the weight of the crop, a great number of trials have proven the efficiency of the bouillie bordelaise. Prillieux obtained with nine plants :—

TABLE XL.—*Showing the Effect of Bouillie Bordelaise on the Potato Disease.*

Diseased Plants.	*Number of Tubers.*	*Diseased Tubers.*
Treated	115	9
Untreated	80	26

Steglich tried this treatment on six different species, planted in plots of 50 square metres, and in all cases obtained yields of from 10-80 per cent higher than that of the untreated plot. The treatment consisted in three sprayings : on 12 June, 17 July, and 15 August. Andra,

working on a field of 0·428 hectare, about 1·06 acres, obtained with one spraying:—

TABLE XLI.—*Showing the Effect of One Spraying of Bouillie Bordelaise on the Weight of the Crop of Magnum Bonum Potatoes.*

Species.	*Plants.*	*Tubers, Lb.*
Magnum bonum	Untreated	7750
,,	Treated	10100

The cost of the treatment came to 3s. per acre, and the net profit to 57s. per acre. Mark, who experimented on fifty varieties, got an increased weight of crop of from 30-50 per cent. Stroebel found a higher yield of 48·7 per cent, and only 0·28 per cent of diseased tubers, against 5·8-23·3 per cent in the untreated field. Honeyball found a greater yield of 7-30 per cent. Finally in America and Switzerland the same effects have been realized, and this treatment is applied on the large scale in these countries as well as in France, in the whole valley of the Garonne, where it gives full satisfaction. Doubts as to the efficiency of the treatment of the phytophthora by the bouillie bordelaise are now no longer permissible; too many experiments show that applied at the moment of the evolution of the disease, it completely prevents it from spreading, thus preserving the crop so greatly compromised when the disease spreads normally. It is recommended not to apply the first spraying except at the moment when the first spots of the disease appear on the leaves. But it is better to make a first preventive spraying. The number of sprayings to be practised during the year is only regulated by the prevailing weather. If the year be moist and warm, conditions essentially favourable to its evolution and to very rapid spreading of the disease, it will be well to make several sprayings, only eight to fifteen days apart. During dry periods spraying is useless, and in the case of a very dry year, during which the disease does not assume a disquieting extension, a single preventive spraying may be regarded as sufficient. Scientists do not agree as to whether spraying is beneficial when the disease is not to be feared. Sorauer, an advocate of spraying at the time of the appearance of the diseases, has shown that if the infected fields treated in time yield a much greater number of tubers than untreated fields, it is no longer so when a field which is neither threatened nor invaded by the disease is treated. Sorauer experimented on perfectly sound tubers, which gave, before the appearance of the disease, a crop absolutely exempt from diseased tubers, whilst these same plants yielded, after the evolution of the disease, 59·4 per cent of diseased tubers. These experimental fields gave before and after treatment:—[1]

[1] Part of the potatoes of both plots were lifted before the disease appeared.

TABLE XLII.—*Sound Plants, Showing Number, Weight, and Size of Large and Small Potatoes before the Appearance of Disease.*

Plants.	*Large Tubers.*		*Small Tubers.*	
	Number.	*Weight.*	*Number.*	*Weight.*
Treated	28	843	102	752
Untreated	38	1337	43	423

TABLE XLIII.—*Diseased Plants, Showing Number, Weight, and Size of Large and Small Potatoes after the Appearance of the Disease.*

Plants.	*Large Tubers.*		*Small Tubers.*	
	Number.	*Weight.*	*Number.*	*Weight.*
Treated	45	1450·8	92	810·8
Untreated	33	1191	91	1191

According to this table the untreated sound plants, i.e. the tubers of which were lifted before the disease appeared, gave a greater yield of tubers than those treated with bouillie bordelaise. Sorauer explains this fact by a certain degeneration of the leaf, very characteristic, which is the result of treatment with cupric compounds. This degeneration is especially pronounced when the bouillie used still contains unconverted blue vitriol, or when sprayings are made with a soluble salt such as acetate of copper. Sturgis got the following results with various copper preparations :—

TABLE XLIV.—*Showing the Effect of Various Copper Preparations on the Bulk of the Potato Crop, and the Number of Diseased Potatoes.*

Per Cent.		*Bushels Per Acre.*	*Diseased Tubers.*
1 1 0·1	Blue vitriol Lime Emerald green	286	0
0·5 0·1	Blue vitriol Lime	269·5	0
0·15 0·06	Copper acetate Emerald green	181·5	0
0·125 0·250	Blue vitriol Ammonium carbonate	156	0

Sorauer advises not to spray early varieties, generally lifted before the disease develops in a threatening manner, for the treatment would not only be useless, but might lower the weight of the crop. Frank

and Kruger are of a contrary opinion. They have shown that sound potatoes sprayed several times in the year, have a more vigorous growth and a greater vitality than untreated plants. The copper treatment increases the crop of tubers (Gutzeit), even in dry seasons, when the disease is not to be feared, in the ratio of 100 to 163, and according to Leydhecken by 2 per cent. These observers reckon that the bouillie bordelaise treatment is imperative in all cases, because it is always followed by an increased crop, whether the copper acts as a stimulant of the plant or whether it prevents the invasion of parasites, so numerous as to lower the assimilative capacity of the leaves by the greater or less damage which they produce in them. The disinfection of seed potatoes, and the treatment of the stems with bouillie bordelaise, always protect the cultivator from those sudden outbursts of potato disease, and enables him to produce uniformly good crops. The phytophthora does not attack potatoes alone, but other plants of the *Solaneæ* family, such as the tomato (*Licopersicum*). What has been said as regards the potato applies to this plant. Pellegrini successfully treated this disease with a bouillie of 3 per cent blue vitriol and 1 per cent of lime. By three sprayings on tomatoes already attacked, the first on 15 June, the second on 2 July, and the third on 15 July, Howell succeeded in getting 4 per cent of diseased fruit on the treated plot, against 60 per cent on the untreated plot.

Phytophthora Phaseoli, Thaxter (Lima bean mildew).—This phytophthora devastates the haricot (*Phaseolus lunatus*) fields of America. Sturgis treated this fungi successfully with bouillie bordelaise.

Peronospora viticola, De By. (mildew of the vine).—If the water favourable to the development of the spore contains the most minimum amount of copper the conidia does not hatch, or if it hatches, the germination tube cannot penetrate into the leaf. The object of the bouillie bordelaise treatment is thus to prevent the conidia from forming new hotbeds of infection by stopping its evolution. It will be seen that the amount of copper to be deposited on the leaves need not be great to produce this effect, and that a weak bouillie bordelaise may have the same action as the concentrated bouillie formerly used. But it is not possible to go below certain limits. Trials made with 0·5 per cent, and even 0·1 per cent, have shown that, if the action of the copper is still perceptible, with 0·1 of blue vitriol in the bouillie bordelaise, that strength can no longer entirely prevent the hatching of the disease. After the use of a 0·5 per cent bouillie there may still remain some rare leaves attacked by mildew. The 1 per cent bouillies, on the contrary, are always sufficient, and absolutely as efficient as the classical 2 per cent bouillie. In most cases this 1 per cent bouillie is used. The 0·5 per cent bouillie is used when the treatments exceed five in a year. By seven treatments with a 0·5 per cent bouillie, Galloway got 99 per cent of sound grapes. It is, in fact, better to renew a thin copper deposit on the leaves and grapes often than to spread a thick layer two or three times a year; the organs are continually growing, and washed by the rains. The great point is to cover all the surface of the vine uniformly with bouillie bordelaise by

copious and careful spraying. The first treatment can only preserve the leaves touched ; the vine continues to grow, fresh applications are required to preserve the organs developed between the intervals of spraying. The treatment is oftener, and at shorter intervals, the more intense the growth. In the South of France, the heat of summer often stops all growth of the vine at the same time as the extension of the disease. This stoppage coincides with the second, or frequently with the third, treatment. In Central France, on the other hand, where the heat is less intense, and the summers more rainy, the vine grows without interruption the whole summer. There the number of treatments ought to be much greater to preserve all the new leaves as developed. It is necessary to protect the grapes in the same way to prevent "rots". These also must be covered early with a coating of cupric hydrate. If in hot countries three sprayings be sufficient, in the centre and in moist years a fourth and fifth treatment is required. A sixth and seventh treatment is useful, especially when frequent rains remove part of the copper deposit. In a dry year the moisture of autumn renders a treatment necessary before the vintage. It is especially recommended for young plants particularly sensitive to mildew ; this treatment enables them to retain their leaves longer and completely ripen their wood. In districts exposed to sea-winds, which are very favourable to this disease, as many as nine treatments are given. No general rule can be laid down as to the number of sprayings; it varies with the year and the district. The first treatment must be applied before the appearance of the disease, for, owing to its rapidity of spreading, it is sometimes too late when seen on the leaves. To be efficient it should be applied in the second fortnight of May. The second is applied towards the end of June, shortly after flowering, but it should never be done during flowering. Mildew being most formidable in June, it is thus the second spraying which should be applied with the greatest care, and most abundantly. These treatments must, according to the weather, be followed by one or several others, the last of which should be applied a fortnight before the vintage. The fear, formerly expressed, that this last vitriolizing might change the properties from a hygienic point of view, has been found unjustified. Millardet and Guyon, then numerous chemists and hygienists, have shown that copper salts sprayed on grapes are conveyed in very small amount into the vat, and are almost totally eliminated in the lees after the fermentation of the wort. Whatever may be the strength of the bouillie bordelaise, the wine only contains traces of copper, which can have no injurious effect on the health of the consumer. Since 1891 the treatment of mildew by bouillie bordelaise is compulsory in the canton of Vaud in Switzerland. There is a similar order in the Grisons. The prefect of Savoy has, likewise, ordered three obligatory sprayings, the first on 20 June, the second on 20 July, and the third on 20 August. The good effect of spraying is lauded in Italy by Hugues, Cuboni, Briosi, and Pichi, in Switzerland by Dufour, in Austria by Schachincher, in Russia by Chmjelewski, and in America by Galloway.

Peronospora Schachtii (mildew of the beet).—Mr. Fuckel Just

treated this disease by sprayings of 0·5 and 0·75 per cent of bouillie bordelaise with a slight excess of lime. Girard found, by treating beet-fields by a bouillie bordelaise with 3 per cent blue vitriol and 5 per cent lime, if not a total increase in the weight of the crop, at least ½ per cent more sugar. On 35 acres, of which 4 per cent of the beets were diseased, 5 hectolitres (110 gallons) of 3 per cent bouillie gave the above good results.

Peronospora gangliformis, De By. (lettuce disease).—Sulphur, formerly used by kitchen gardeners, having no action on this blight, the mycelium of which lives in the interior of the leaves, it has been tried to treat it with copper preparations. Young lettuce leaves are very delicate. They require as much care as vine leaves, and the bouillie must be prepared with great care. To be effective the treatment must be preventive. When the bed is prepared, either for sowing or transplanting, it is watered with a 4 per cent solution of blue vitriol, or with a 4 per cent bouillie so as to reach all the surface parts. The bed in contact with the plants is thus disinfected. During growth a very neutral bouillie, made with 0·5 to 1 per cent of blue vitriol, is spread on the plants in the evening or in cloudy weather. The effects are not so categoric as those obtained in the treatment of mildew of the vine. The exceptionally favourable conditions to the development of the *Peronospora gangliformis* created by kitchen gardening, its rapid growth demanding several treatments close to one another, the fact that the conidia do not give rise to the formation of zoospores, generally ten times more sensitive to copper salts than the conidia themselves, are the causes of some failures.

Peronospora Viscine, De By. (mildew of the pea and the bean).—Treated by spraying as soon as the spots appear on the leaf.

Peronospora arborescens, De By. (mildew of the poppy).—Treated by bouillie bordelaise before the appearance of the disease (Nijpels).

Peronospora Schleideni, Ung. (mildew of the onion).—Spraying with bouillie is effective (Nijpels).

To sum up, bouillie bordelaise forms an excellent means for treating and preventing mildews. These diseases all have the same method of dissemination by summer spores which enables them to become deadly to crops in a comparatively short time, especially in a moist, warm season. They should be treated preventively by bouillie bordelaise at the moment the first symptoms of the disease appear, or better still, before their appearance at the epochs propitious for the rapid spread of this fungus. Applied with care bouillie bordelaise always gives a perceptible and useful result, paying liberally for the cost of the treatment. A single spraying cannot produce immunity for the whole year, and if it be desired to preserve the plants from all attacks this treatment should be applied judiciously each time that the weather is favourable to a deadly extension of this fungus.

Plasmopara cubensis, B. et C. (mildew of the cucurbitaceæ).—This fungus attacks *Cucumus sativus*, *Melo cucurbita maxima*, *Citrullus vulgaris*.—It may be treated by bouillies bordelaises repeated several times a year. Selby, Halsted, Sirrine, and Stewart obtained good

results. The latter produced by this treatment 102,000 vegetable marrows instead of 20,000 on an untreated plot of the same size.

Ustilagineæ.—After the fortunate results obtained by vitriolizing corn-seed by Kuhn's method, consisting in steeping in a solution of blue vitriol followed by washing in milk of lime, it was interesting to treat corn-seed with bouillie bordelaise. Experiments in this direction show that the action of cupric hydrate is, so to speak, *nil.* That is not at all surprising seeing that the spores of the *Ustilagineæ* are much more resistant to copper compounds than the spores of the *Peronosporeæ.* In treating the different mildews the object of spraying with bouillie bordelaise is to prevent the spores from germinating and penetrating into the vulnerable organs. The bouillie bordelaise cannot destroy the very resistant zoospores or dormant spores but only the extremely sensitive zoospores. Besides it cannot kill the winter spores of the *Ustilagineæ* which infect grain, and only in an indifferent manner hinders their germination; it cannot, therefore, prevent them from penetrating into the young plant which it does not protect. Hence Kellermann and Swingle declare after many trials that bouillie bordelaise cannot replace blue vitriol in the disinfection of corn-seed. Bedfort obtained the same negative result. After steeping oats-seed in bouillie bordelaise made with 2 per cent blue vitriol and 2 per cent lime there were as many "rust" ears as sound ears, whilst seed from the same source disinfected the same day by 2 per cent formaline produced no diseased ears. In the preventive treatment of *Ustilago maydis*, Corda (rust of maize), Halsted found a diminution in the disease but not its total suppression. Bouillie bordelaise cannot, therefore, as recommended by Van Tubeuf, replace blue vitriol in the disinfection of corn-seed.

Uredineæ (rusts).—Bouillie bordelaise has been used with greater or less success to treat some species of rust. The object of spraying with the bouillie bordelaise was to prevent the summer spores of the aecidium and uredo from germinating and spreading the disease. Bouillie bordelaise cannot be used practically to combat the more deadly rusts.

Rusts of Cereals.—Numerous trials by Galloway, Swingle, and Bartholomew, both with bouillie bordelaise and cupric borate, cupric ferrocyanide or eau celeste, trials which consisted in practically spraying every ten days the whole plant, gave no satisfactory result. This check is attributed to—

1. The difficult adherence of the bouillie on the cereal grain. Even if sugar, gum, or glue be mixed with bouillie bordelaise, the plant cannot be covered with a layer of cupric hydrate capable of preventing the germination of the spores to be found there.

2. The strength of the ordinary bouillies, 0·5-2 per cent, which is quite insufficient. To obtain an appreciable result very strong bouillies must be used, made with about 8 per cent of blue vitriol. These might have an immunizing action on cereals, and prevent the disease, if the great expense and the practical difficulty did not remove this treatment from cultural methods. Galloway, Kellermann, and Cobb

thus obtained by spraying every ten to twenty days, from 28 October to 24 June, on winter wheat fields free from rust. Swingle found that the proportion of plants attacked by rust is thus lowered from 84·2 to 18·3 per cent. It is useless to dwell upon the failure of bouillie bordelaise as a disinfectant of corn-seed against rust germs; not only does it have no effect, but it is quite useless in treating a fungus, the method of evolution of which is so different from that of the black rust, and which has methods of propagation which can only diminish the effect of disinfection.

Puccinia Pruni, Pers. (rust of stone-fruit trees).—Pierce successfully treated this fungus by three sprayings with bouillie bordelaise at a month's interval. The spraying was begun before flowering. Trees so treated preserve their green leaves.

Puccinia compositarum, Schlechtend (mildew of the compositæ).—It is successfully treated with bouillie bordelaise.

Puccinia Tanaceti, D. C.—Successfully treated by Halsted.

Puccinia Ribis, Aecidium Grossulariæ (mildew of the gooseberry).—Sorauer recommends preventive treatment by bouillie bordelaise. Eriksson recommends removing the diseased leaves in the autumn, and to spray soil and plant copiously in the spring.

Uromyces Betae, Kuhn (beet mildew).—Nijpels relates that three sprayings with bouillie bordelaise at a month's interval, commencing in June, appreciably diminished this disease.

Gynosporangium Sabinæ, Wint. (mildew of the juniper), and *Roestelia cancellata*, Rebent (pear leaf cluster cups).—Knowing the polymorphism of this uredinæ it has been recommended to overcome this disease by destroying all the juniper-trees on which the fungus exists in its telento and uredo forms, so as to prevent the evolution of the fungus. It is sometimes made to disappear in that way, but very often the disease appears on the pear-tree, when there are no junipers in the district. It is then necessary to resort to spraying with bouillie bordelaise. The experiments of Weiss and Delacroix have shown that this process is evidently, if not absolutely, efficient. The first spraying ought to be made before the unfolding of the leaf, the second before flowering, and the third at a month's interval.

Peridermium Pini, Wall. (vesicular rust of pine bark).—In addition to the destruction of swallowort and groundsel, preventive sprayings with bouillie bordelaise in May have given such good results that this method has been adopted by the Belgian Forestry Department to prevent this disease in pine plantations.

Exoascus deformans, Fuckel.—It has been suppressed by the use of bouillie bordelaise. Benton, Taft, Selby, Duggar, Derschau, Murill, and others, have examined the action of copper compounds on the leaf curl and described the good effects got by rational application of bouillie bordelaise. It follows from their experiments that the bouillie bordelaise is the more active the sooner it is applied. The first spraying should be done before flowering in March and April, when the buds begin to swell. At that time strong bouillie made with 3 per cent of blue vitriol may be used; however, 1 per cent bouillie would suffice (Murill). The second spraying is done after the fall of the flowers, with

a bouillie made with 0·5 per cent of blue vitriol. The third spraying, if necessary, should take place when the leaves have reached their normal size. The result of these operations is not always complete the first year, but the second or the third year the "cloque" will disappear if care has been taken of the trees in this way. The "cloque" will not again appear if one or two preventive sprayings are given every year. The beneficial action of bouillie bordelaise is surprising. It is generally allowed that cupric sprayings can exert no destructive action on fungi, the mycelium of which grows in the interior of the tissues. The preventive use of bouillies in different diseases should have no other object than to preserve the tissues, by preventing the spores which are deposited thereon from producing the disease. It is otherwise in regard to the leaf curl, where the bouillie is used as a curative agent. We know so little as to the method of propagation of the "cloque" (the artificial infection of peach-trees by spores has never succeeded) that we cannot exactly define what is the rôle played in its suppression by spraying with bouillie bordelaise. We believe, however, that, in this case the copper compounds deposited on the peach-trees destroy the mycelium of the leaf curl. The peach behaves in a special way towards cupric compounds. It can dissolve insoluble cupric deposits on its organs in quantities poisonous to the fungi and itself. It follows that the effect of the bouillie bordelaise on the health of the plant is identical with that produced by spraying with pure blue vitriol. In most cases the use of cupric bouillie, even that of weak bouillie bordelaise, produces the partial or total fall of the leaf reached by the preparation. Those which do not fall are riddled with holes, or seriously attacked. Are we to admit that the mycelium, which almost crawls on the leaf, since it is lodged between the epidermis and the cuticle, and is very little protected by the tissues, undergoes the first poisonous action of the salts of copper absorbed by the leaves? Or must it be admitted that the action of the bouillie bordelaise results solely from the fact that the mycelium localized in the leaves is necessarily suppressed at the same time as the disease by the fall of the leaves? In our opinion beneficial action of bouillie bordelaise results from the two following facts: (1) destruction of the mycelium of the *Exoascus* lodged in the buds in the spring; (2) its suppression, by the fall of the infected leaves in which the disease is localized. The fall of the leaves, incidental to the treatment, has no deadly action on the evolution of the tree, and there is nothing at which to be alarmed. The copper absorbed by the plant stimulates it, and causes a more rapid and more intense growth, so that the tree in summer and in autumn would be more vigorous than untreated trees. We therefore possess in bouillie bordelaise a curative remedy for the leaf curl of the peach, a remedy which may be of great service to gardeners. We insist, therefore, on this point, that the treatment to be complete should extend several years, and should enter into the common customs of the orchard. Not only the cryptogamic diseases of the peach will be suppressed, but the quite exceptional vigour of the trees treated will enable better crops to be secured than on untreated trees.

Exoascus Pruni (pockets of the plum).—Sturgis asserts that he obtained a radical cure of the disease by bouillie bordelaise.

Erysiphe communis, Wallr. (mildew of the pea).—This mildew is successfully treated by sulphur. Nijpels asserts that one or more sprayings with bouillie bordelaise likewise cures the disease.

Uncinula americana, How. (oidium of the vine).—The mycelium crawls on the surface of the leaf and there produces its organs of reproduction. It was possible that this fungus, protected less than any other by the tissues of the nurse plant, might be readily destroyed by copper salts. It was also hoped to be able to suppress the sulphurating used against this disease by replacing it by vitriolization. This process would have much simplified the dressings required against the cryptogamic diseases. Neither blue vitriol nor cupric hydrate have, however, any curative or preventive action on this fungus, and it vegetates quite as well on leaves covered with bouillie bordelaise as on untreated leaves. The treatment for mildew being an absolute failure against oidium, it remains necessary to continue the sulphurating of the vines at the same time as the vitriolizing with bouillie bordelaise. Up to 1902 it was thought preferable to separate the two treatments. It seemed in the beginning that there was no drawback in the fact that one of the operations was conducted before the other, and it was the sulphuring, as the oldest known, with which the vine-growers began; but in considering the mechanical phenomena which are produced in this case on the surface of the leaf, it will be understood why it is necessary to precede the first sulphuring by vitriolizing. If the first treatment be sulphuring, the sulphur deposited on the leaves mechanically fixes a large part of the bouillie, which will not adhere to the leaves, and forms large uncovered spaces. There is really neither complete sulphuring nor vitriolizing. If, on the other hand, we vitriolize first and sulphur as soon as the spray is dry, the adherence of the sulphur is increased, and the two remedies have their full action on the cryptogamic diseases which they should overcome. To simplify the work of the vine-grower it has been tried to unite these two treatments in a single one; say by mixing the sulphur with finely pulverized copper salt, or by mixing the sulphur in the cupric bouillie. In the beginning the use of these mixtures often gave negative or very incomplete results, so that Polacci, P. Viala, Mach, and Marès have condemned them as unfit to cure or preserve the vine from oidium or mildew, because the copper salts by seizing the vapours of sulphur poisonous to the oidium converted them into copper sulphide, inert towards mildew. In 1902 Guillon reported to the Academy of Sciences the altogether satisfactory results obtained with sulphurated bouillie bordelaise in the Charente. Without denying the reactions which may occur between copper derivatives and sulphur, Guillon has, however, observed that these are slow to occur, and that bouillies sulphurated immediately after their preparation may act simultaneously on the two diseases before the sulphur has acted on the cupric hydrate. To mix the sulphur in the bouillie it is necessary to moisten it suitably. For this purpose water or the bouillie must be allowed to fall, drop by drop, on the sulphur whilst stirring. It is, however, preferable to

incorporate it in the milk of lime. By adding the sulphur gradually to the milk of lime a yellow, homogeneous paste is obtained, which is afterward run into the solution of blue vitriol. This operation of moistening sulphur is, moreover, now simplified by the use of the moistenable sulphurs of commerce, the composition of which is as follows:—

TABLE XLV.—*Showing Composition of Moistenable Sulphur.*

	Lb.	*Lb.*
Sublimed sulphur	70	85
Carbonate of soda	20	10
Powdered rosin	10	5

By adding, at the time of application in the vineyards, 2 lb. of the moistenable sulphurs to 1 lb. of blue vitriol in solution, there is obtained forthwith a sulphurated bouillie bourguignonne. This bouillie, used as soon as made, possesses the double property of preventing oidium and mildew. The more freshly made the more it adheres. The amount of sulphur used in these sulphurated bouillies, as Guillon, Cucovitch, and Gervais have shown, should not be more than 2 or 3 per cent. But these bouillies have one defect, the sulphur tends to deposit; on the other hand, they have the advantage of containing perfectly neutral sulphur, which can no longer burn the leaves. The sulphuric acid contained in the sulphur, and which is often the cause of these burnings, is, in fact, often neutralized in these bouillies by the lime or by the carbonate of soda. So the direct producers most sensitive to sulphur, which generally cannot be sufficiently protected against oidium, behave well towards sulphurated bouillies. The latter, by the readiness by which they lend themselves to the simultaneous treatment of different cryptogamic diseases, constitute a real progress. Their use enters more and more into current practice, the more so as the results obtained by Guillon are confirmed. Cucovitch pointed out, in fact, at the International Agricultural Congress held at Rome, in 1903, the very decisive results obtained against mildew and oidium with a bouillie of 1 per cent of blue vitriol, 1 per cent of lime, and 2 per cent of sulphur. Prosper Gervais likewise submitted his vineyard of Causses to this new treatment, and found four treatments of sulphurated bouillie act as well as four sulphurings and vitriolizings as ordinarily performed. The first treatment took place before flowering, when the twigs of the stem had reached 12 inches. The second was made after flowering, as soon as the fruit became apparent. The third in the first fortnight of July, and the fourth in the first fortnight of August. A single sulphuring, abundant and penetrating, was made at the time of flowering, by means of Vermorel's torpedo, against the dropping of fruit and accidents of fertilization. According to the experiments of Hoc, Quantin, Trabut, and Seignouret, it would appear that the mono- and polysulphides of copper also act on oidium and mildew, from which it would appear that the sulphurated bouillie must act in any case. It is, however, acknowledged that sulphurated bouillies containing no sulphur compounds of copper render the most regular service in the struggle against these two diseases. In spite of its notorious failure against oidium of the vine, bouillie borde-

laise is recommended to overcome the fungi of the same family as oidium. Thus Selby recommends bouillie bordelaise to overcome:—

Podosphæra Oxyacanthæ, D. C., blight which invades the apple and the cherry tree in America, but which in Europe only produces the hawthorn blight.

Sphærotheca Morsuvæ, Berk et Courte (blight of the gooseberry), which invades the fruits of this shrub in North America to such an extent as to entirely destroy the crop.

Sphærotheca pannosa, Lev. (mildew of the rose-bush and peach-tree).—The reports of cures obtained by treatment with bouillie bordelaise are numerous. Ritzema Bos, Nijpels, and Speschneff recommend this treatment to overcome this disease. Nijpels recommends bouillie bordelaise to overcome:—

Microsphæra Grossulariæ, Wallr. (mildew of the gooseberry).—However, bouillie bordelaise will not act so efficiently and decisively as sulphur at a high temperature, and cannot be advantageously used to overcome blights.

Hypomyces perniciosus, Magnus (mole disease).—This disease causes considerable damage in mushroom beds. Constantin and Dufour submitted the spores of this injurious fungus to the action of bouillie bordelaise and found that prolonged steeping in a 2 per cent bouillie does them little harm, and it is only after three to seven days' steeping that the spores are killed.

Nectria ditissima, Tul. (canker of the pear, apple, and beech trees); *Spæropsis malorum*, Peck. (apple rot, pear rot, quince rot).—To prevent these diseases Selby and Paddock recommend to scrape the trunk of the trees, to clean the wounds, and to spray the whole tree with bouillie bordelaise. This process has no action on already formed cankers. Only their deep excision, followed by coating the living wounds with a concentrated solution of green vitriol, acidulated by sulphuric acid, can suppress them and cure the tree.

Polystigma rubrum, D. C. (plum leaf blister).—Sorauer and Nijpels recommend to prevent this disease to carefully burn the dried leaves and to spray preventively with bouillie bordelaise on the young spring leaves, or on the branches before the opening of the buds.

Guignardia Bidwelli, Viala et Ravaz (black rot of grapes).—In 1887 trials were made at Ganges with blue vitriol. In spite of the negative results of these trials the experiments were resumed the following year at Aiguillon with bouillie bordelaise on a certain number of black-rotted vines in 1887. After three sprayings, made before the end of July, the stocks treated only had 14-24 per cent of diseased grapes, whilst the untreated vines which surrounded them had 95-99 per cent. Great publicity was given to these fortunate results, so as to enable vine-growers to take in time the necessary steps to prevent the extension of black rot around the hotbeds of infection. Experience shows that bouillie bordelaise does not act on black rot as on mildew. The summer spores of black rot being much less sensitive to the action of cupric preparations than the zoospores of mildew, it is necessary to use stronger bouillies and spray more often. This fungus may develop, like mildew, with unheard-of rapidity,

and cause irreparable damage in forty-eight hours. The time of treatment should thus be chosen with circumspection, and the number of sprayings subordinated to weather favourable to the evolution of the parasite in question. Whilst dry, cold weather may completely stop black rot, on the other hand, moist, warm weather gives it full scope. It is therefore at such a time that it is most advisable to spray, and continue to do so at very short intervals. If in most cases three sprayings suffice, seven to ten are required in moist seasons (Prillieux and Viala).

Dussuc advises the use of the following sprays :—

TABLE XLVI.—*Showing the Composition, Volume Per Acre, Time of Treatment, and Order of Sequence of Bouillies Bordelaises used in the Prevention of Black Rot of Grapes.*

Order of Treatments.	*Gallons of Solution Per Acre.*	*Strength Per Cent of the Solution.*		*Time of Treatment.*
		Blue Vitriol.	*Lime.*	
First	17·6	3	3	May
Second	26·4	4	3	June
Third	35·2	5	3	July
Fourth	44·0	6	3	August

Dussuc believes the above gradually increasing quantities, used at the different times of spraying, are indispensable, so as to cover the entire surface of all the green parts of the vine. One of the essential conditions of success rests, in fact, on the care taken to spare neither the upper nor under surface of the leaves. When the vines have tufts which prevent the uniform penetration of the liquid, they should be further treated with powders containing blue vitriol and sulphur. By alternating the spraying with bouillie bordelaise and with powders, the results obtained leave nothing to be desired. Lamson, Scribner, and Pearson recommend, in America, four to five sprayings, the first of which is made on 5 May, and the last in autumn. Trials on the large scale made in America by 250 vine-growers secured to them a profit of £7400 (Galloway). The 4-6 per cent bouillies, used in the beginning, are now abandoned and replaced by 2-3 per cent bouillies. In France four treatments are the rule, and should be applied at the following periods in most instances (Couderc) :—

TABLE XLVII.—*Showing Order, Time of Spraying, and Strength of Bouillies in Treatment of Black Rot of Grapes* (Couderc).

Order of Treatments.	*Time of Spraying.*	*Strength of Bouillies, Per Cent.*
First	First week of May	2 Blue vitriol, 2 lime
Second	Second week of May	2 Blue vitriol, 2 lime
Third	Last fortnight of June	3 Blue vitriol, 2 lime
Fourth	Last fortnight of July	3 Blue vitriol, 2 lime, 2 molasses

These epochs have been fixed according to the periodical development of black rot. Prunet, who examined black rot very closely, points out the parallelism between the evolution of the parasite and that of the vine, and has based on this fact a rational course of treatment, here given in full. The first invasion especially attacks the leaves, which on the vine branches, the first shot forth, are included between the third and the eighth; the second attacks chiefly those included between the tenth and the eighteenth, and in addition the pedicles of the flower and grape stalks; the third attacks the fruit when they are the size of a big pea, and also the leaves above the eighteenth; finally, the last attacks the fruit when of almost normal size. With such data, we ought to operate according to the intensity of the disease.

I. In the most intense hotbeds of disease.
II. In spots attacked rather strongly.
III. In those attacked feebly, or to an average extent.

I.	1st	sulphating	when 5-7	leaves on first branches.
	2nd	,,	,, 7-9	,, ,,
	3rd	,,	,, 10-13	,, ,,
	4th	,,	,, 15-18	,, ,,
	5th	,,	,, the grapes	show themselves.
	6th	,,	,, ,,	are big as a large pea.
	7th	,,	,, ,,	are almost full size.
II.	1st	sulphating	when 5-8	leaves on first branches.
	2nd	,,	,, 10-13	,, ,,
	3rd	,,	,, 15-18	,, ,,
	4th	,,	as soon as grapes appear.	
	5th	,,	when grapes are size of pea.	
III.	Does not differ from preceding except by suppressing second treatment.			

Where vineyards have been treated as soon as the disease appears success is complete and the disease easily overcome. However, if the formidable fungus has been allowed to develop without any obstacle before treatment, the perithecae which spread the disease are so numerous that very often ten treatments do not give a complete result. This is especially the case when by negligence the black-rotted grapes have been left on the stock. It is thus advisable to support the spring and summer treatments by energetic winter treatments and by precautions which complete these treatments. In spring and in summer the spotted leaves must be removed; if one is surprised by the disease remove the buds and young branches from the stock so that the stem may be better aerated, and that the axillary sprouts do not form a dangerous neighbourhood for the grapes. In winter the leaves and attacked grapes left on the stock must be burned, then the stocks must be treated as for anthracnose by concentrated and acidulated solutions of green vitriol, so as to destroy, if possible, all the perithecae which the following year transmit the disease to the vine. The strong doses of blue vitriol which enter into the composition of the bouillie used to combat black rot render the struggle against this disease very onerous, and almost impossible in districts where low quality wine is produced at a low price. Numerous trials have, therefore, been made with weak bouillie. In America especially it has been tried to overcome

black rot with the bouillies in use against mildew, and encouraging results have been obtained. Galloway submitted different vines to the different treatment summed up in the following table:—

TABLE XLVIII.—*Showing Results of Repeatedly Spraying Vines with Blue Vitriol Solutions of Various Strengths.*

Composition of Bouillie, Per Cent.	*Number of Sprayings.*	*Date of Spraying.*	*Sound Grapes, Per Cent.*
3·25 blue vitriol	6	27 April, 13 May, 25 May, 9 June, 22 June, 7 July	94
1·6 „	6	27 April, 13 May, 25 May, 9 June, 22 June, 7 July	93
3·25 „	4	27 April, 13 May, 25 May, 9 June	89
1·6 „	4	27 April, 13 May, 25 May, 9 June	90
3·25 „	3	9 June, 22 June, 7 July	22·5
1·6 „	3	9 June, 23 June, 7 July	13·5
Untreated	—	—	1·1

These experiments show plainly that the concentration of the bouillies is less important than the frequency of sprayings, and the choice of the time at which they are executed. Trials with 0·5 per cent bouillies gave favourable results, and Ecluse recommends to overcome black rot by the classical treatment for mildew, provided the first May spraying be done with a bouillie of 6 per cent of blue vitriol and 3 per cent of lime. It is not impossible for weak bouillie to give good results, but it must not be forgotten that in many cases the struggle is difficult, and the treatment applied against mildew is impotent against black rot. We therefore believe that it is indispensable to follow the method so carefully studied by Prunet, consisting in the use of 2 per cent bouillies, a method capable of entirely preventing black rot, and of which the efficiency against mildew is absolute.

Coniothyrium Diplodiella, Sacc. (white rot, pale rot, livid rot).—Although the preventive or curative treatment against this disease gives imperfect results, none the less it is recommended by Viala and Sorauer. But its application is difficult, because to obtain a satisfactory result the preventive sprayings on the grape must be done immediately after the formation of the wounds on the grape stalks, so as to prevent the spores from penetrating into the wounds.

Alternaria Solani, Sor.; *Macrosporium Solani*, Ell. et Mart.—Rolfs, Weed, Selby, Burrill, McClure, Earle, and Galloway declare that bouillie bordelaise overcomes this disease. Galloway advises a bouillie of 1·5 per cent blue vitriol and 1 per cent of lime. The first spraying is done with care, before the spots appear on the plant, so that all the leafy surface is covered with cupric hydrate.

Alternaria Brassicae f. nigrescens, Peglion (scorching of the leaves of the melon).—The use of bouillie bordelaise was advised by Peglion. It gives good results. The first spraying should be given the moment

the small spot appears on the leaves and young shoots, and the second fifteen to twenty days later. A better result is obtained by adding a little sugar or ammonium chloride to the bouillie. Smith recommends in this case 1 lb. of sugar or $\frac{1}{2}$ lb. of ammonium chloride to 15 gallons of water.

Sphærella Fragaria, Sacc. (spots of the leaf of the strawberry).—Garman advises to overcome this disease a bouillie bordelaise with 3·25 per cent of blue vitriol and 2 per cent of lime, used to spray every fifteen days until it disappears. Weiss has shown that a 1 per cent bouillie suffices when used as spray before flowering, and after gathering the fruit. This bouillie is very adherent on the strawberries so that it cannot be used during the formation of the fruit, which could not be sold.

Cylindrosporium Padi, Karst. (cherry and plum leaf blight).—This disease which, in America, causes the leaves of plum-trees and pear-trees to fall, is effectively overcome by three sprayings with bouillie bordelaise in July and August (Selby). According to Galloway and Pammel the bouillie bordelaise is a specific remedy against this disease. The best is a bouillie of 1·25 per cent of blue vitriol and 0·8 per cent of lime. According to Fairchild and Sorauer the trees should be sprayed five times—the first before the opening of the leaves, the following with fifteen days' interval. It is essential that the bouillie cover the two faces of the leaves.

Sphærella morifolia, Passerini (*Cylindrosporium Mori Bert*), (mildew of the leaves of the mulberry).—Bouillie bordelaise 5 per cent gives excellent results (Caruso).

Septoria.—Trials against these diseases show that bouillie bordelaise, judiciously applied, is an excellent method for overcoming them, especially if the first spraying be applied preventively before the opening of the young leaves.

Septoria Tritici, Desm., and *Septoria graminum*, Desm. (nielle des cereales).—Kruger steeped the spores of the pycnides for twenty to forty hours in a 2 per cent bouillie bordelaise and found that they did not germinate after this treatment. Galloway observed a diminution in this disease in treating grain against rust by cupric preparations.

Septoria Ribis induces the premature fall of gooseberry leaves.

Septoria Rubi, Wert., produces pale spots bordered with red on raspberry and blackberry leaves. Selby, Goff, and Pammel overcame this fungi by spraying with bouillie bordelaise. May be overcome in the same way :—

Septoria Lycopersici, Speg. (spots of the tomato leaf).—Selby, Halsted, and Earle.

Septoria Petroselini, Desm. (pale spots of the parsley).—Duggar and Bailey.

Septoria Cerasina, Peck. (spots of the leaf of the plum-tree, cherry-tree, apricot, and peach-tree in America).—With three sprayings there is a marked but incomplete effect. Spots of the leaf of the chrysanthemum in Italy by five to six sprayings, containing a little soap.

Septoria nigerrima, Fuckel, and *Septoria piricola*, Desm. (white spots bordered with brown on the pear-tree).—According to Sorauer

this disease is overcome by several sprayings, the first of which is given before the opening of the buds. According to Weiss by a spraying before and after flowering. This treatment is better than by potassium sulphide (Duggar).

Gloeosporium Ribis, Mont. and Desm. (currant leaf spot).—Weiss advises to overcome this disease preventively by two sprayings, the first before the opening of the buds, the second after flowering.

Gloeosporium curvatum, Oudem. (disease of the leaves of the gooseberry).—Sorauer recommends the preceding preventive treatment by bouillie bordelaise.

Gloeosporium Juglandis, Mont. (walnut leaf disease).—Injurious to young plantations, it is combated preventively by spraying with bouillie bordelaise (Sorauer).

Gloeosporium venetum, Speg. (raspberry spot, in America).—Selby and Green recommend preventive treatment with bouillie bordelaise.

Gloeosporium frutigenum, Berk. (bitter rot of the apple).—Garman and Stinson overcome this disease by four sprayings, the first before the fall of the petals, and the three others at fifteen days' interval.

Gloeosporium phomoides, Sacc. (anthracnosis of tomato, in America). —Halsted advises spraying with bouillie bordelaise.

Gloeosporium macropus, Sacc. (orchid disease, especially the varieties Laelia and Cattleya).—Mangin advises a 2 per cent bouillie bordelaise.

Amongst the great number of *Phyllosticta*, Pers., which are characterized by the small round spots which they form on their nurse plants, only the following have been tried with bouillie bordelaise:—

Phyllosticta sphæropsidea, Ell. et Ev. (horse chestnut [*Æsculus Hippocastanum*] leaf disease).—Fairchild has used bouillie bordelaise as a preventive with success.

Phyllosticta Pirina, Sacc. (pear-tree leaf spots).—Weiss has overcome this disease with bouillie bordelaise.

Fusicladium Pirinum, Fuckel (pear scab); *Fusicladium dentriticum*, Fuckel (apple scab).—It is very important for orchards to prevent this disease. The knowledge of the evolution of these fungi enables it to be overcome preventively. It is above all necessary to prevent the transmission of the disease from one year to another by destroying the holed branches, the spotted leaves and fruit, on which are formed the winter spores which infest the young organs of the new vegetation in the spring. This wise precaution is far from sufficient. The whole tree must be disinfected chemically by covering all its parts with a concentrated solution of green vitriol, acidulated by sulphuric acid, say with a concentrated bouillie bordelaise containing 4-5 per cent of blue vitriol and as much lime. Ricaud was the first, in 1866, to treat fruit trees with bouillie bordelaise. He advised to treat the walls and the trellises against which the trees are nailed up in the same way. It is almost indispensable to spray the soil copiously around the tree in autumn and spring, so as to disinfect the surface layer of soil, on which numerous germs of cryptogamic disease always fall with the leaves. A soil containing 4 per cent of bouillie bordelaise in no way affects the germination of

seeds which may be afterwards sown around the trees. There are no vexatious consequences to be feared (Frank and Weiss). Winter treatment, however well done, does not exclude the different summer treatments required to prevent this disease entirely. Physiologists who have studied the question advise two spring sprayings with bouillie bordelaise. Stinson by three sprayings, the first of which was at the end of April, the second in the middle of May, and the third in the beginning of June, got 95 per cent of healthy apples and 5 per cent of spotted ones, whilst 91 per cent of the apples on the untreated trees were attacked. Maxwell found seven sprayings were required to cause the disease to disappear entirely.

TABLE XLIX.—*Showing the Effect of the Number of Sprayings with Bouillie Bordelaise on the Percentage of Diseased Pears.*

	Spotted Pears, Per Cent.
Trees sprayed twice yielded	3·17
,, ,, three times yielded . . .	3·57
,, ,, seven times yielded . . .	0·00

The bouillies recommended in the beginning by Ricaud were made from blue vitriol 2 per cent and lime 3 per cent. But apples and pears, particularly those which were grafted on quince-trees, were too sensitive for these bouillies. The strength has been greatly reduced and equally satisfactory results got with 1 per cent or even 0·5 per cent. Taft ascribes the corrosive action of these bouillies on the leaves of apple and pear trees to the excess of lime which they mostly contain ; he therefore advises absolutely neutral bouillies. Muller found that whilst pure cupric hydrate produced symptoms of poisoning on the plant, a 4 per cent milk of lime had no effect. He observed that bouillies containing little blue vitriol (say 0·5 per cent) and much lime (4 per cent) produced less burns than neutral bouillies, even of 0·5 per cent.

The object of multiple treatments is to cover not only the leaves and the young shoots with bouillie bordelaise, but also the young fruits. The number of sprayings evidently depends on the weather, as in the treatment of the vine against mildew and black rot. If frequent rains wash the leaves and fruit, and favour by moisture the development of summer spores, sprayings should be more frequent than in warm, dry weather. The first treatment is before flowering, the second immediately after flowering, and the third when the fruit is the size of a pea. Since 1886 Goethe, Mohr, Kruger, Caruso, Peglion, Lodeman, Munson, Taft, Sturgis, Stinson, Beach, Prillieux, Nijpels, Hotter, Sorauer, Muller, etc., have demonstrated the absolute efficiency of treatment with bouillie bordelaise against the scab. Galloway, Fairchild, and Beach have more especially observed the physiological effect produced on the tree by spraying. The ravages of the *Fusicladium* must not be looked at from a mere money point of view, because they render the fruit unmarketable. Like all leaf parasites they do damage to these organs of assimilation and injure the health of the tree. The life of the plants is concentrated, on the one hand, in the leaves, and on the other hand, in the roots. Between

these organs there exists an admirable correlation when they are intact, but as soon as one of these cannot fulfil its physiological functions, the other suffers. If the leaves are killed by parasitic fungi the roots cannot do their part. The sap which ascends, however rich it may be, cannot nourish the plant if this sap is not elaborated by the leaves ; respiration is affected, assimilation is defective, the alimentation of the different organs of the plant by the descending sap is inefficient ; if the leaves fall or are entirely destroyed life ceases. It is therefore important to prevent all wounds on the leaf, to stimulate their development, and to keep them as long as possible in a state of health. That is realizable if the many sprayings with bouillie bordelaise are included in the necessary and normal dressings of fruit trees, as in the orchards of Sweden and America. A tree regularly and systematically treated with bouillie bordelaise keeps its leaves healthy. By its stimulating effects cupric hydrate prolongs the vitality of the leaves until late in the season, and the growth of the trees being thus prolonged, become more vigorous than those which have not undergone this treatment. The amount of copper required to produce this remarkable physiological effect is almost infinitesimal, and the bouillies used need not be prepared with more than 0·5 per cent of blue vitriol. Fruit trees being very sensitive to pure blue vitriol, it is necessary that the bouillie bordelaise be prepared with great care.

Fusicladium Cerasi, Sacc. (black spots of the cherry).—Sirodot recommends the treatment and precautions used against apple and pear spots.

Entomosporium maculatum (leaf scald of pear and quince tree) ; *Entomosporium Mespili*, Sacc., or *Morthiera Mespili*, Fuckel (spots of the leaf of the pear).—The fruit trees are treated as indicated for *Fusicladium*. Galloway, Pearson, Chester, Sturgis have made several trials in this direction. They show that by several sprayings annually the ravages of this fungus may be prevented. In the beginning a 3 per cent bouillie of blue vitriol and 2 per cent of lime was used ; but it was found that weaker bouillies are capable of rendering the same service. Maxwell obtained the following results with a 2 per cent bouillie :—

TABLE L.—*Showing the Effect of Repeated Spraying with a 2 Per Cent Bouillie Bordelaise on the Percentage of Diseased Pear-Tree Leaves.*

	Percentage of Diseased Leaves.
Untreated trees	75·84
Twice treated trees, 25 April, 9 May	3·17
Three times treated trees, 14 April, 25 April, 9 May	3·17
Seven ,, ,, ,, 14 April, 25 April, 9 May, 5 June, 25 June, 14 July, 5 August	0·00

To prevent great damage two sprayings suffice ; but the disease is not entirely stopped until after multiple treatments. Waite advises a single treatment at the right time, that is to say, when the leaves are two-thirds of their normal size. Fairchild lowered the strength of the bouillie to 1·2 per cent of blue vitriol and as much lime, and obtained the same favourable result by repeated sprayings as with

concentrated bouillie. Sorauer and Stoll also found excellent results from bouillie bordelaise used before the opening of the leaves.

Colletotrichum Lindemuthianum, Br. and C. (anthracnose of the haricot and scarlet runner).—Beach overcame this disease preventively before sowing by steeping the haricot beans in bouillie bordelaise, and afterwards spraying the plant with a weak bouillie of 0·8 per cent of blue vitriol and 0·5 per cent of lime. The first spraying was done before flowering, and the succeeding ones at fifteen days' interval, avoiding, however, spraying on the flowers, as the fructification would be hindered by the bouillie.

Colletotrichum oligochætum, Cav. (*Nuile* or anthracnose of the melon).—Sprayings with bouillie bordelaise produce no effect if used curatively (Prillieux); on the other hand, by their preventive use Selby and Halsted obtained excellent results.

Cercospora Apii, Fr. (celery leaf spots).—This disease causes much damage in America, and methods of defence against it have been studied in that country. Halsted advises bouillie bordelaise, Duggar and Bailey bouillie bourguignonne.

Cercospora Beticolæ, Sacc. (beet leaf spots).—Halsted recommends spraying with bouillie bordelaise.

Cercospora Resedæ (mignonette leaf spots).—Fairchild advises a preventive treatment, consisting of three sprayings with a bouillie of 3·25 per cent of blue vitriol and 2 per cent of lime.

Cladosporium fulvum, Cooke (tomato leaf rust).—Curative treatment by cupric preparations is inefficient. On the other hand, a preventive treatment removes the disease. The evolution of the disease is slow. Spraying must be done early on the absolutely healthy plant (Galloway), and fresh spraying done every week (Rolfs). Selby, Halsted, Nijpels, and Earle point out the good effects of preventive treatment with bouillie bordelaise.

Cladosporium Cucumerinum, Ell. and Art.—Frank did not obtain favourable results with cupric preparations, because the spores of this fungus have a great resistance to copper salts. Selby, on the contrary, was quite successful.

Cladosporium Carpophilum, Thüm. (spots of the cherry, plum scab).—Selby advises bouillie bordelaise to overcome it like *Fusicladium*.

Cycloconium Oleaginum, Castagne (olive leaf spots).—At the Agricultural Institute of Pisa 200 olive-trees were successfully treated against this disease with a 0·5 per cent bouillie, used four times in July, then in September, October, and November. The olive-trees so treated preserved their leaves intact, whilst the untreated had suffered much from the parasite. Vennuccini advises two preventive treatments, the first with a 1 per cent bouillie in winter, the second with a 0·5 per cent bouillie in spring. Brizi confirms the good results got by this treatment.

Heterosporium echinulatum, Cooke (fairy ring of carnations).—Selby overcomes this disease by bouillie bordelaise.

Lophodermium Pinastri, Chev. (pine leaf cast, fall of the needles of the pine).—In 1888 Bartet and Vuillemin found in bouillie borde-

laise an excellent method for preventing this disease. Their experiments in the Bellefontaine Nursery, near Nancy, gave very decisive results. Two treatments with bouillie bordelaise on two to three-year-old plants, the first beginning in June, when the needles are half formed, the second a month later, when they are fully developed, assured the complete immunity of the young plants, whilst 80 per cent of the untreated succumbed to the disease. Beck and Osterheld tried this treatment on a larger scale, and as far back as 1889 this process entered into the forestry practice of Bavaria. Von Tubeuf likewise controlled the efficiency of cupric preparations on an experimental field at Dahlem. His experiments show that bouillie bordelaise produces more effect in August than in June or September, and that it was superior to other cupric preparations. Bouillie bordelaise cannot destroy the mycelium developed in the interior of the plant, but it protects the sound needles of a pine-tree already invaded by the disease. Young plants which still have the greater portion of the leaves may be preserved if the healthy leaves are protected by energetic spraying at the moment when the new shoots have reached two-thirds of their height. The first treatment should be given in June, the succeeding ones very carefully in July and August, for it is at that time that the invasion is the most intense, and that the leaves should be entirely protected by a layer of cupric hydrate.

Sclerotinia Cydoniæ, Schell.—This disease invades quinces and mummifies them. It may be overcome by spraying the tree before the opening of the leaves (Sorauer).

Monilia frutigena, Pers. (brown rot of kernel fruits).—To prevent this disease the mummified fruits, brown before the harvest, must be collected in winter and carefully destroyed, for, as shown by Galloway, brown rot can only be overcome with difficulty by bouillie bordelaise and other anticryptogamic products. Chester, by six sprayings a year with a big bouillie, from 29 April to 2 July, found that the number of diseased fruit was lowered from 32 per cent to 13 per cent; but that the disease cannot be entirely prevented. Montemartini likewise found the bouillie inefficient. Schoyen advises against this disease spraying before the opening of the buds.

Botrytis cinerea (vine sclerotinia).—Bouillie bordelaise is generally regarded as inefficient against the mould of grapes in autumn. Sorauer and Beauverie believe that, above all, the air should be allowed to penetrate more easily around the fruits by partially stripping the leaves and in cutting the shoots around the grapes, and to spray afterwards.

Use of Bouillie Bordelaise against Insects.—Cupric hydrate, deposited uniformly on the green parts of a plant, protects these against the attacks of insects and their larvæ. Plants regularly treated by bouillie bordelaise are less sought after than untreated plants. After eating leaves blued by a deposit of cupric hydrate insects and their larvæ are poisoned and die. The contact and the presence of copper are so disagreeable to them that they often quit the tree after treatment with copper hydrate. Thus the caterpillars of the *Hyponomeute* of the apple abandon the silky gauze which serves to them as a shelter,

and let themselves fall on the ground after spraying with bouillie bordelaise (Sonnino). The *Eriocampa adumbrata* (slug-worm or slimy caterpillar), the caterpillar of the *Liparis chrysorrhea*, L., that of the *Gastropacha neustria* (the lackey or barred tree lackey moth), are killed, according to Goethe, by the absorption of the blued leaves. The *Leptinotarsa decemlineata* (Colorado beetle) may be overcome by bouillie bordelaise. The trees sought after by the anthonome of the apple-tree may be protected by spraying with bouillie bordelaise (Montillot). The vines treated regularly by bouillie bordelaise are abandoned by the *Altise* and the *Pyralis* (d'Andoque de Sériège, Martini). In general injurious insects are seen to diminish greatly in gardens where the trees are treated with cupric bouillie. Debray advises spraying with 2 per cent bouillie bordelaise to destroy *Cassida viridis*, L. (coleoptera injurious to artichokes) and the caterpillars of the *Pierides*, injurious to the crucifers, rapes, cabbages, turnips, etc. This preparation has also been used successfully against the gooseberry saw-fly, *Tenthredo Grossulariæ*. It also diminishes the number of the *Eriophyes Piri*, Pgst., which cause the "cloque" of the pear-tree, and destroys the insect injurious to melons and vegetable marrows, *Diabrotica vittata*, Fab. (Sirrine). Its action is less decisive against plant lice and cochineals. By suppressing the fruit-tree smut, which accompanies the invasions of the cochineals of the olive-tree, orange-tree, rose laurel (Pastre), and vine (Targioni-Tozzetti), it removes the greatest infliction incidental to the parasiticism of insects. Bouillie bordelaise does not, however, suppress the cochineal. Bouillie bordelaise is regarded by Dr. Menudier, Mohr, and D'Angelo as sufficient to remove the phylloxera. D'Angelo has used this process in the island of Elba with full success. The treatment comprised two sprayings of the stock with a bouillie bordelaise of 1·8 per cent blue vitriol and 1 per cent lime, and three sprayings with a 5 per cent solution of blue vitriol containing sulphur. Bouillie bordelaise is not frequently used for the destruction of insects, because it is not so energetic in its action as poisonous substances. Bouillies with a Scheele's green or emerald green basis, which contain both copper and arsenic, are preferred. Bouillie bordelaise possesses, to a certain extent, the insecticidal properties of arsenical bouillies. It likewise acts on the stomach of the insects which absorb it. To intensify its action organic insecticides are added to it; thus Martini reports that 2 per cent bouillie bordelaise, to which 1·5 per cent of rubinia or carbolated tobacco juice was added, instantaneously kills cochylis of the vine. After one of these sprayings there were only 5·61-7·87 per cent of grapes with caterpillars, whilst after a single treatment with pure bouillie bordelaise, there were still 24 per cent.

CHAPTER XV.

EAU CELESTE—COPPER PHOSPHATE—COPPER BORATE—COPPER FERROCYANIDE.

92. Eau Celeste.—Preparation.—By dissolving a copper salt in water and treating the solution with an excess of ammonia a pale celestial blue precipitate of copper hydrate forms, then an intense celestial blue solution. Eau celeste is an ammoniuret of copper oxide dissolved in water. Audoynaud, who first advised this liquor to replace bouillie bordelaise in the struggle against cryptogamic diseases, prepared eau celeste by dissolving 10 lb. of blue vitriol in 3 gallons of hot water, cooling the solution, then adding about $1\frac{1}{2}$ gallons of commercial ammonia. The concentrated eau celeste thus obtained keeps indefinitely. When required for use it is diluted with 200 gallons of water. Bellot des Minières advised for the preparation of eau celeste another method of manufacture, that of Schweizer's cupro-ammoniacal liquor, which is endowed with the remarkable faculty of dissolving cellulose. This method is based on the property of ammonia of dissolving metallic copper in presence of air, producing cuprammonium hydrate. A funnel is filled with red copper turnings, and ammonia of 22° Baumé poured on the top. The ammonia is passed and repassed several times over the copper. The solution is not finished until after a great many passages. With 1 lb. of copper 15 gallons of anticryptogamic liquor is produced. To distinguish it from the eau celeste of Audoynaud, this solution is termed "Bellot des Minières ammoniaco-cupric liquor," or "ammoniate of copper". Copper carbonate likewise dissolves in ammonia, and the blue solution so obtained dissolves cellulose, like Schweizer's liquor, whilst, on the contrary, the ammoniuret of copper hydrate, prepared from the sulphate nitrate, or the phosphate of copper, is not endowed with this special property. The anticryptogamic liquor obtained by dissolving copper carbonate in ammonia is called *eau celeste modifiée*, or ammoniacal carbonate of copper bouillie. Its preparation is more simple than that of any other copper bouillie, for it suffices to weigh a certain quantity of commercial copper carbonate, stir it up with the necessary water, and add ammonia to complete solution. The same result is obtained by adding ammonia to bouillie bourguignonne until it is converted into a deep limpid blue liquor. In America it is customary to dilute ammonia to 26° B. with seven to eight times it weight of water, and to add copper carbonate whilst stirring until a small amount remains insoluble—a proof that the liquor does not contain an excess of ammonia, a condition which is not attended to in the greatest number of instances. If it be desired to prepare modified

eau celeste from blue vitriol, Mohr's process is followed: Dissolve 3 lb. of blue vitriol in hot water and add gradually, after cooling the solution, 1 lb. of soda ash, then 12 fl. oz. of ammonia of 24° B.; dilute the blue liquor to 100 gallons. The same liquor is obtained by adding sodium carbonate to ordinary eau celeste or in mixing a solution of 1 lb. of blue vitriol in 50 gallons of water, with 2 lb. of ammonium carb nate in 50 gallons of water. Liquors with an ammoniuret of oxide of copper basis thus vary greatly, both as to strength and method of manufacture. When they are prepared it must not be forgotten that dry carbonate of copper contains 51 per cent of copper, whilst blue vitriol which crystallizes with 5 molecules of water, only contains 25 per cent. So that a bouillie may have the same copper content twice as much blue vitriol must be taken as copper carbonate. A bouillie bordelaise said to be a 1 per cent bouillie, that is, made with 1 lb. of blue vitriol to 10 gallons of water, ought to be compared in its cryptogamic action with a 1 per cent ordinary eau celeste, and with a 0·5 per cent modified eau celeste made from copper carbonate, these bouillies containing the same dose of metallic copper.

Properties.—Compared with bouillies eaux celestes have the great advantage of being limpid solutions, containing neither precipitate nor deposit capable of choking the spraying machines, or of being deposited at the bottom of tanks or vessels. Eau celeste is more easily used than bouillie bordelaise, the more so as it is made a long time beforehand in a concentrated condition and can be kept indefinitely in that state. Formerly, bouillie bordelaise contained a large excess of lime, which rendered its application exceedingly difficult. Eau celeste had properties which had to be considered and which gave it a real advantage. At that already distant time 0·5 per cent eau celeste ran much cheaper than 2-3 per cent bouillie bordelaise. Eau celeste could also be more uniformly distributed than thick bouillie. Finally, the adherence of the thin pellicle of copper hydrate, which is formed after the evaporation of the ammonia from the surface of the organs covered with liquor, is much more perfect than that left by bouillie bordelaise, and resists, according to Rossel, rains of seven to eight hours' duration. All these advantages were of a nature greatly to encourage the use of eau celeste at a time when bouillie bordelaise was not sufficiently studied. Now it is otherwise. Carefully prepared, bouillie bordelaise does not now contain an excess of lime; it has no more than 0·5-1·0 per cent of blue vitriol, and thus no longer has the great drawbacks of the original bouillie bordelaise, so that all the comparative advantages of eau celeste have almost disappeared. The advocates of eau celeste, especially the ammoniaco-cupric liquor, and the modified eau celeste, assert that eau celeste of this special composition is more active than bouillie bordelaise, because it dissolves cellulose, and would thus, by contact with the organs, disintegrate them and destroy them much quicker than ordinary cupric bouillies. This opinion is very much open to question. If it really were so, it would be easy to determine the superiority of modified eau celeste and any other analogous preparation endowed with the extraordinary properties of Schweizer's reagent of dissolving cellulose. In opposition to this enticing theory there must

first be placed the results of the comparative trials made with cupric anticryptogamics not endowed with this property, such as bouillie bordelaise and bouillie bourguignonne. They do not establish practically the sporicidal superiority of eau celeste. Millardet and Gayon obtained the following results:—

TABLE LI.—*Showing the Effect of Spraying Vines with Eau Celeste, on the Density of the Wort, the Weight of the Wort per Kilogramme of Grapes, the Sugar Content per Litre of the Wort, and the Weight of the Grapes.*

Vines.	*Method of Treatment.*	*Density of Wort.*	*Weight of Wort per Kilogramme of Grapes in Grammes.*	*Sugar per Litre of Wort.*	*Kilogrammes of Grapes.*
Marcin	Three times with ammoniate	1·060	667·8	120	76
,,	Twice with bouillie bordelaise	1·070	719·6	178·5	120
Malbec	Three times with ammoniate	1·083	739	208	142
,,	Twice with bouillie bordelaise	1·088	755	213·5	148

Secondly, highly dilute solutions of these cupric compounds do not dissolve cellulose unless after long maceration, and moreover, thirdly, the organic matter of which the cells of fungi consist is not cellulose, but an analogous substance which has not the same reactions as cellulose. Even if it be admitted that the liquor of Bellot des Minières can dissolve spores in contact with the solution, the method of application is against these properties being exercised. Sprayings, in fact, spread a thin layer of this liquor on the surface of the leaves; the ammonia evaporates forthwith, and there remains on the leaves insoluble cupric hydrate, with no solvent action on cellulose. The solvent action of this liquor only lasts a very short time, which would enable it to act curatively at the moment it is projected on to the diseased organs. The application of these preparations in the full evolution of mildew has produced immediate curative effects, which would plead in favour of a special action of which bouillie bordelaise and bouillie bourguignonne are deprived, but it is known that blue vitriol solutions exercise to the same extent a curative action on this disease. Solutions of copper hydrate in ammonia or in other alkalies have quite peculiar properties. Thus Bellot des Minières' preparation of a certain strength, like *eau celeste modifiée*, dissolves cellulose, and a solution of 5 parts of blue vitriol in 100 parts of water, added to 5 parts of glycerin and a sufficiency of caustic potash to redissolve the precipitate first formed and give an azure solution, possesses the remarkable property of dissolving natural silk. From there to the conclusion that this preparation should be the most perfect insecticide is but a step, since it can dissolve the shell of the insect, the composition of which is very analogous to that of silk. This insecticide, which has not yet been tested in actual practice, would only decompose very slowly, and might act energetically on insects. [Mouillefert has found

that ammoniacal sulphate of copper, although more active against phylloxera than blue vitriol, does not kill it, and Pearson reports that eau celeste removes the *Macrodactylus subspinosus* injurious to rose bushes.] Along with all these properties just described eau celeste has grave drawbacks. It is, above all, blamed for causing serious burns, especially when the treatment has to be applied very early. This fact is especially to be dreaded when eau celeste is spread in moist weather when it therefore dries slowly on the leaves; on the other hand, when the sprayings are applied in the strong heat of summer, this defect entirely disappears, and eau celeste is in every way advantageous. These burns, in fact, are easily explained. It has been seen under blue vitriol that the poisonous action of cupric preparations on plants was the more pronounced the more soluble they were in water. Eau celeste contains a cupric compound, as soluble as blue vitriol, and the effect produced at the moment of spraying is thus equally unfavourable to the plant. It is likewise admitted that blue vitriol is poisonous, owing to the sulphuric acid which it contains, and which, in bouillie bordelaise, is fixed and rendered harmless by the lime. Although sulphuric acid may contribute to a certain extent to the corrosive action of blue vitriol, it is not the chief poisoning principle. For the same reason it is generally admitted that eau celeste burns the leaves, because the sulphuric acid of the blue vitriol used in its preparation is fixed by the ammonia, and that this unstable salt, in decomposing, liberates sulphuric acid, which then burns the leaves. This hypothesis is one of the chief reasons of the use of copper carbonate in place of blue vitriol in the preparation of eau celeste; the latter, in fact, burns the plants much less than ordinary eau celeste.

There is thus great analogy between the action of blue vitriol and eau celeste, both on the plants and on the fungi to be overcome. From the beginning of the use of eau celeste it was to be seen that a solution made from 0·5 per cent of blue vitriol sufficed to produce the desired effect; the doses have diminished in certain cases as far as 0·1 per cent of blue vitriol. With such solutions burns are no longer to be feared. In contrast to blue vitriol, which, as it dries on the surface of the leaf, forms small crystals, which dissolving in the dew yield concentrated solutions, burning the leaves where these crystals are accumulated, the eau celeste deposits cupric hydrate on evaporation. The defect of burning the leaves only exists for the eau celeste for the time during which the sheet of liquid takes to dry. As soon as dry the ammonia which holds the copper oxide in solution evaporates, leaving a residue of cupric hydrate, which covers the surface of the leaf and protects it against spores. If rain falls it is only beneficial, because far from dissolving or detaching the cupric film, it only dissolves and removes the sulphate of ammonia, the action of which on the plant may be injurious. Eau celeste, compared with blue vitriol solutions, therefore, possesses the advantage of leaving an adherent deposit on the surface of the leaf, and whilst equally efficacious at the moment of use, has a much more durable action. With an equal dose of blue vitriol, it requires fewer sprayings with

eau celeste than pure blue vitriol, which renders this treatment less costly than those in use. There is, however, a third cause, which explains the poisonous action of eau celeste on plants. Whether prepared with or without an excess of ammonia the eau celeste, in drying, disengages ammonia on the surface of the organs attacked, and in greater quantity the greater the excess of ammonia. Now, ammonia is injurious to plants; as soon as the air contains a doze exceeding 70 milligrammes per cubic metre of air, it causes burns already described. To replace bouillie bordelaise with advantage eau celeste should not be made from more than 0·5 per cent of blue vitriol or 0·25 per cent of copper carbonate nor with an excess of ammonia. To be certain that an excess of ammonia has not been used it is well only to add such an amount as will not entirely re-dissolve the precipitated copper hydrate. The chances of burning are thus much diminished. Besides, it is well only to use eau celeste in fine dry weather, so as to let the thin layer of liquid spread on the surface of the plant. To get an eau celeste free from sulphate of ammonia this liquor is prepared as follows (Prillieux): Precipitate the blue vitriol as cupric hydrate with half the quantity of ammonia used in making eau celeste; let this celestial blue precipitate deposit; decant the clear limpid supernatant liquid, which contains all the sulphate of ammonia; add water equal in volume to the bulk of the liquid removed, and add the remainder of the ammonia to dissolve the precipitate; an eau celeste is thus obtained which contains little or no sulphate of ammonia. The same result is obtained by adding to a 0·5 per cent bouillie bordelaise the ammonia required to dissolve the precipitated cupric hydrate, then decanting the dark blue supernatant limpid liquid after some time from the deposit formed by the excess of lime and sulphate of lime. This eau celeste no longer contains traces of sulphuric acid nor of sulphate. By taking these precautions in the preparation of eau celeste, and only using it rationally, this liquor is excellent, and especially cheap. A drawback of eau celeste is that it leaves no decisive mark on the leaves. Eau celeste is especially advised to combat cryptogamic diseases in full evolution in circumstances where the use of bouillie bordelaise would have no effect. In such cases its special properties, its energetic action on the conidiophores and on spores, produce the best results. Its corrosive action on the leaves in the dose required to stop the first attack of fungi in the spring, will always cause it to be inferior to neutral bouillie bordelaise, but in summer, when burns are not to be feared, the second and third treatments for the year are advantageously made with eau celeste.

Eau celeste is, therefore, in the hands of the cultivator, a powerful agent for overcoming cryptogamic diseases in full evolution, whilst bouillie bordelaise is par excellence the preventive remedy which should protect the plant, by killing the germs which are deposited on its surface.

Use.—The use of eau celeste has found numerous advocates in France and Switzerland. *Eau celeste modifiée* has in America in many cases replaced bouillie bordelaise.

Phytophthora infestans, De By. (potato disease).—Mohr advises to

overcome this disease in full evolution, 3 lb. blue vitriol, 1 lb. 80-85 per cent soda ash, and 12 fl. oz. of ammonia of 24° B. in 10 gallons of water. Spraying is done in the morning as soon as the dew has evaporated. A dilute solution, used in July, will not burn the leaves.

Peronospora viticola, De By. (mildew of vine).—Eau celeste affords cheap summer treatment, especially to stop a sudden outbreak. Mohr advises for June spraying an eau celeste prepared thus : Dissolve $1\frac{1}{2}$ lb. of blue vitriol in 2 gallons of water, add first 8 fl. oz. of ammonia, 24° B., then the solution of $\frac{3}{5}$ lb. of 80 per cent soda ash, and make up to 10 gallons. July and August sprayings are made with an eau celeste consisting of 2 lb. of blue vitriol, 9·6 fl. oz. of ammonia, 12 oz. of calcined soda, and 10 gallons of water. In the opinion of several observers a 0·4 per cent eau celeste suffices. Prillieux doubts its efficacy and prefers a stronger eau celeste to produce an effect on the disease in full evolution and an advantage over bouillie bordelaise. Kalas' results with bouillie bordelaise are in a general way better than those obtained with eau celeste. Vines strongly attacked by mildew are greener after treatment with bouillie bordelaise than after eau celeste.

Peronospora gangliformis, De By. (lettuce disease). — Kitchen gardens often have to suffer from this disease. It would be prevented, according to Prof. Maxime Cornu, by covering the soil with a layer of shavings or straw, previously impregnated with eau celeste. Dung from mushroom beds ought to be drenched with eau celeste, then drained, before being used for lettuces.

Puccinia graminis, Pers. (rust of wheat).—Galloway has examined the effect of eau celeste on the evolution of rust, and made the interesting remark that winter wheat, treated every ten days by spraying with eau celeste, is completely freed from rust, whilst it remained attacked when the sprayings were at twenty days' interval. In this last case the diminution of diseased plants was only $33\frac{1}{3}$ per cent. These results were disputed by Swingle.

Puccinia Pruni, Pers. (plum leaf rust).—Pierce reports that this rust is successfully overcome by an eau celeste of blue vitriol 1 lb., ammonia 26° B. 12 fl. oz., carbonate of soda $1\frac{1}{4}$ lb., in 100 litres of water.

Podosphæra Oxycanthæ, D. C.—Pammel reports that he prevents the fall of the leaves incidental to this disease by ten sprayings, from 6 June to 4 August, on grafted cherry-trees and Mahaleb plums with *eau celeste modifiée*. The thirty-five plants treated had 4498 leaves against 1195 on the untreated samples.

Sphærotheca Humuli, Burr. (strawberry blight).—Humphrey obtained a complete cure of attacked plants and a recrudescence of verdure by treatment with bouillie bordelaise containing 0·4 per cent of carbonate of copper and 2 per cent of carbonate of ammonia.

Guignardia Bidwelli, V. and R. (black rot of grapes).—Galloway got good results by the following treatment: Modified eau celeste, containing 0·1 per cent of copper carbonate dissolved in ammonia and used in four sprayings, 30 April, 15 May, 30 May, and 14 June. The total of the diseased grapes was reduced to 0·6 per cent, against 45 per cent on the untreated stocks.

TABLE LII.—*Showing Composition of Galloway's Eau Celeste.*

Blue vitriol	3 lb.
Soda crystals	3 ,,
Ammonia	2½ ,,
Water	100 gals.

Galloway's bouillie applied in six sprayings in fine weather, in eight sprayings at fifteen days' interval in bad weather, was still more active.

TABLE LIII.—*Showing the Percentage of Sound Grapes on Untreated Vines, and on Vines Treated by Eau Celeste made by Two Different Formulæ.*

	Percentage of Sound Grapes.
Untreated vines	38·3
Vines treated by eau celeste, formula I	91·32
,, ,, ,, ,, II	98·06

Gloeosporium frutigenum, Berk. (bitter rot of apples).—Goff and Nijpels state that three sprayings with eau celeste is a sufficient protection for apples.

Fusicladium dentricum, Fuckel (apple scab).—Galloway and Goff caused this disease to disappear entirely with four sprayings of eau celeste containing 45 grammes of copper carbonate dissolved in ammonia per 100 litres of water [45 parts by weight in 100,000 parts by measure]. It is necessary to make the first spraying before blossoming, the second immediately after blossoming, and the two last at fifteen days' interval.

Fusicladium pirinum, Fuckel (pear scab).—These are overcome in the same way (Mohr).

Entomosporium maculatum, Lev. (leaf scald of the pear-tree).—This disease may be removed by spraying with an *eau celeste modifiée* containing copper carbonate 1 lb., ammonia 26° B. ¾ lb., water 100 gallons. To prevent burning the leaves an excess of ammonia must be avoided. Pammel recommends as many as eight sprayings, 8, 20, and 27 June, 9, 11, 18 and 21 July, and the last 1 August.

Colletotrichum Lindemuthianum, Br. and C. (anthracnosis of the haricot, etc.).—According to Halsted, modified eau celeste acts better than bouillie bordelaise against this disease. In Canada a peculiar system of disinfecting seed haricot beans is used. It is an eau celeste containing about 1 per cent copper carbonate dissolved in the necessary amount of ammonia. The results obtained by one hour's disinfection are as follows:—

TABLE LIV.—*Showing the Result of Disinfecting Haricot Bean Seed with Eau Celeste.*

	Percentage of Plants Reared.	*Healthy Pods, Per Cent.*
Disinfected haricots	73	79
Untreated ,,	84	43

Cercospora circumcissa, Sacc. ("shothole fungus," spots of the leaf of the plum-tree and almond-tree).—Galloway reports that an eau celeste containing 1·42 lb. of copper carbonate dissolved in 204 gallons of water and the necessary ammonia may be used against disease of the peach and almond trees, because it scarcely burns the leaves. To

overcome the *Cercospora* a first treatment is given as soon as the leaves appear, the second ten days later, and a third at fifteen days' interval. Pierce thus obtained 80-98 per cent of healthy leaves against 2-8 per cent on the untreated.

Cercospora angulata, Wint. (spots of the leaves of the gooseberry). —Pammel got good results by seven sprayings made between 6 June and 15 August.

Septoria Rubi, West. (spots of the leaf of the bramble and raspberry bushes).—Whilst the raspberry is sensitive to the action of eau celeste, good results are obtained if it is used to combat the *Septoria* of the bramble. Goff obtained the following results:—

TABLE LV.—*Showing the Effect of Spraying Bramble Bushes with Eau Celeste.*

Kind of Crop.	*First Series, lb. of Fruit.*	*Second Series, lb. of Fruit.*
Brambles sprayed six times	224	488
,, untreated . .	168	452

Cladiosporium fulvum, Cooke (tomato leaf rust).—Jenkins and Britton found that modified eau celeste had no good effect, whilst bouillie bordelaise entirely removed this disease.

Lemon Warts.—Swingle and Weber advise modified eau celeste to prevent lemon warts. For this purpose they advise the first treatment after the fall of the petals, the second two or three weeks later, the third after the fall of the last flowers, and the fourth when the fruits are the size of a pea. In moist weather favourable to the extension of the disease, it is necessary to multiply the treatments.

93. Phosphate of Copper, $CuHPO_4$.—**Preparation.**—By adding a solution of phosphate of soda to a solution of blue vitriol.

Use.—Fairchild prepared a bouillie by precipitating 4 lb. of blue vitriol by 7 lb. of phosphate of soda, and made the bulk up to 100 gallons. This preparation whilst having the properties of bouillie bordelaise, covered the leaves better than that preparation. In the treatment of *Entomosporium maculatum*, Lev. (leaf scald of the pear-tree), the bouillie gave good results; it did not seem to damage the leaves. The results obtained by Galloway against the rusts of oats and wheat were not remarkable. The plots treated 6, 16, and 20 June, as well as July, showed no rust, but the yield in grain was only 83 per cent of the usual yield.

94. Borate of Copper, CuB_4O_7.—**Preparation.**—By adding a solution of 50 grammes of borax to a solution of 25 grammes of blue vitriol.

Use.—Copper borate has been recommended by Lodemann; as an antiseptic, and anticryptogamic preparation with the properties of copper salts and of borax. Fairchild used it in a bouillie of 4 lb. of blue vitriol and 4·3 lb. of borax in 100 gallons of water to destroy *Entomosporium maculatum* (spots of the leaves of the pear-tree). This

bouillie adheres better than ammoniacal bouillie bourguignonne. Galloway treated summer wheat and oats against rust by making four sprayings with this bouillie, 6, 16, and 20 June, and 5 July. He obtained plots of wheat with no rust, and yielding 9 units of grain against 8·5 on the untreated plots. With a bouillie containing more borax—it consisted of 70 grammes of blue vitriol and 180 grammes of borax in 100 litres of water—he obtained on winter wheat fields free from rust by spraying every ten days.

95. **Ferrocyanide of Copper.—Preparation.**—By adding a solution of yellow prussiate of potash to one of blue vitriol, until all the copper is precipitated.

Use.—Galloway tried to overcome the rust of winter wheat by spraying the wheat fields every ten days with this preparation. He used a bouillie of 7 oz. of blue vitriol and 16 oz. of yellow prussiate in $62\frac{1}{2}$ gallons of water. By this treatment he diminished the diseased plants 30 per cent. A bouillie consisting of 4 oz. of blue vitriol and 6 oz. of yellow prussiate used in four sprayings, 6, 16, and 20 June, and 5 July, has considerably increased the yield of summer wheat and oats. If fell to 7 units against 8·5 on untreated plots.

CHAPTER XVI.

COPPER ACETO-ARSENITE (EMERALD GREEN, PARIS GREEN)—COPPER ARSENITE (SCHEELE'S GREEN)—COPPER SILICATE—COPPER CARBONATE—BOUILLIE BORDELAISE CELESTE—VERDIGRIS COPPER ACETATE—VARIOUS BOUILLIES.

96. Aceto-Arsenite of Copper, Emerald Green, Paris Green.—Definition.—The aceto-arsenite of copper sold in commerce under the name of [emerald green], "Paris Green," "Schveinfurth green," is a double arsenite and acetate of copper.

Preparation.—By dissolving 4 lb. of white arsenic in 5 gallons of water, and on the other hand, 5 lb. of verdigris in 5 gallons of water, and mixing the two liquids. The mixture is boiled for some time, then a little acetic acid is added. To prepare a bouillie, it suffices to mix 1 lb. of emerald green in a little water, add milk of lime containing 1 per cent of quicklime, and make up the paste to 10 gallons of bouillie. This mixture of cupric hydrate [acetate] and arsenite is much used in America. Commercial emerald green contains 55·34-60·16 per cent of arsenic (As_2O_3) and 27·7-30·9 per cent of cupric oxide (CuO).

Properties.—Commercial aceto-arsenite of copper is not completely insoluble in water, and thus possesses an injurious action on the plants treated. This defect disappears if the acetate of copper be converted into hydrate by quicklime, by mixing the emerald green with lime. Aceto-arsenite of copper freshly prepared is a precipitate fine enough to remain suspended in water. That is not so with the emerald green of commerce. If a bouillie be prepared from the latter, as is generally done, the granular precipitate falls to the bottom of the liquid, and it is necessary to use a sprayer fitted with an agitator to distribute the salt regularly on the trees. Trials by Lintner to determine whether arsenites mixed with soil were absorbed by plants led to the conclusion that plants only absorb arsenites with great difficulty, and only in cases where it is placed in large doses in direct contact with their roots. The aerial organs do not dissolve insoluble arsenites deposited on them by spraying. The ash of potato plants, which has been sprayed with a bouillie of arsenite of copper, does not contain arsenic. Baily obtained the same results with peach-trees treated with emerald green, and Fletcher on apple-trees similarly treated. Scheele's green being insoluble behaves like arsenite of lime. When the product is pure, that is to say, when it contains no unconverted arsenite of soda, its action on plants in insecticidal doses is, so to speak, *nil*, and in many cases it may be employed in 0·05 and 0·1 per cent bouillie. On the other hand, the action of Paris green makes itself felt very energetically when it is not mixed with lime. Baily found that

it is less injurious when very finely divided. Whitehead gives as harmless doses, 40 grammes in 100 litres of water for apple-trees, 45 grammes in 100 litres of water for pear-trees and gooseberry bushes, and 60 grammes in 100 litres of water for plum-trees and currant bushes. (For grammes per 100 litres read also parts by weight per 100,000 parts by measure.)

Peach-trees are the most sensitive to copper arsenites; that is not surprising, since other and even insoluble copper salts, even in minimum doses, induce the total or partial fall of the leaves of that tree.

Action of Arsenites of Copper on Insects.—The arsenite and aceto-arsenite of copper are violent poisons to all insects, which in nibbling the leaves absorb a small quantity.

Use.—Arsenical insecticides have been in use since 1859. In 1872 Dr. Le Baron recommended the use of Paris green against the caterpillar of the citigrade spider. In 1878 Haynes tried this product against the pyralis of the apple-tree, and this trial was followed by those of Cook, Forbes, Alvood, and others. In 1887 the use of arsenical salts was recognized as the most efficient treatment for phytophagous insects. In 1896, 2000 tons of emerald green were consumed in America and 400 tons in Canada. Arsenical sprayings now rarely consist of arsenites alone; they are mixed with substances which facilitate their application by keeping the arsenites in suspension in water or impart to them anticryptogamic properties. The substances with which they are mixed should be of such a nature as not to render the arsenites soluble; thus ammonia eau celeste, pure blue vitriol, soap, and ferric chloride are excluded. A mixture highly valued in America is that of emerald green and bouillie bordelaise. Coquillet advises to increase the adherence by the addition of resins rendered soluble by soda. For the same purpose 2 per cent of molasses may be incorporated or 1 per cent of farina (potato starch). This latter substance has also the advantage of maintaining the precipitate of arsenite of copper longer in suspension in the liquid. Petrol presents no advantage.

Method of Use.—1. *In the Dry State.*—Insoluble arsenites are used in the dry state as powder when the want of water renders spraying the arsenites as bouillies impracticable. To prepare an insecticidal powder 1 lb. of Scheele's green is mixed with 100 lb. of gypsum, 100 lb. of slaked lime, or 67 lb. of farina, or with mixtures of 50 lb. of gypsum and 50 lb. of farina, or with 67 lb. of farina and 33 lb. of gypsum. Dry treatment can only be applied to small-sized plants owing to the danger to the operator. It is very much used in America against the insects of the cotton plant, and various altises, cabbage caterpillars, etc. The insecticide is not so evenly distributed in the form of powder as it is as bouillies; it is done with bellows, hand, or sieve. The operator spreads it whilst walking backwards against the wind. Calm weather is chosen early in the morning when the plants are covered with dew or moistened by rain.

2. *As Bouillies.*—Arsenites of copper are used as bouillies chiefly in arboriculture. It is preferable to precipitate the arsenite of copper on the spot by mixing arsenite of soda and blue vitriol with the addition of a little lime rather than make commercial Scheele's green or

emerald green into a paste. A finely divided precipitate is thus obtained which keeps in suspension and allows the insecticide to be evenly distributed. The best all-round proportions are 0·08 per cent of copper arsenite and 0·08 per cent of lime (8 lb. per 1000 gals.). From 3-5 hectolitres of this bouillie are sprayed per hectare (26·4-44 gallons per acre). Spraying should be done in dry weather without dew and renewed if rain washes the leaves before the insecticide has acted, that is to say, within twenty-four hours. In arboriculture, to obtain the object in view it is necessary to make three to six sprayings per annum. These should be made at epochs determined by the habits of the insect to be overcome.

Precautions.—By an order of 1846 the use of arsenites for the destruction of insects was forbidden in France. But in spite of that injunction, owing to the success obtained in America with these insecticides, their use has extended in France. Arsenites are true poisons which should be guarded against; however, by operating with precaution the treatment ceases to be dangerous. But the operator, after the operation, should wash himself conscientiously, face and hands, and brush his clothes. He should never forget that he is working with a poison. It has been objected, and still is objected in France, that their use on vegetables and on fruits is a danger to the public health. However, in America, where this treatment is practised everywhere no case of poisoning has been reported. The Americans have seriously examined this drawback and made numerous analyses of fruit and vegetables treated with arsenite, but found that the poison does not enter into the plant treated, and that remaining on the surface completely disappears after twenty to twenty-four days. The amount of arsenic spread on plants is so minimum that if they were consumed even shortly after treatment it would require an exceptionally large quantity to produce a poisonous effect. From the analysis of the cabbages treated, Gillette calculated that a person would require to eat 28 heads in a single meal to feel the symptoms of poisoning. In the same way, Riley from experiments made on potatoes so treated, calculated that one would require to eat several 26 gallon barrels to be poisoned. Three weeks after the first treatment Fletcher by analysis found no trace of arsenic on the apples. Plants intended for consumption do not therefore present any danger to the consumer after that lapse of time. However, if such treatment be applied in hot countries prudence must be exercised, for the absence of summer rains might render the presence of this poison on the edible parts of the plant dangerous. Moreover, its use must be avoided during flowering, for the bees and insects indispensable to the fertilization of the flowers risk being killed; further, practice has shown that flowers are rendered sterile if this treatment is applied at the time of blossoming.

Arsenical treatment is excellent when applied on vegetables which are not to be consumed immediately and in countries where frequent rains remove all trace of the poison.

The profit is considerable, for no treatment is more advantageous to the plant. The following figures published in America refer to

orchards only. During the ten years previous, the quantity of apples which without the treatment became wormy was calculated as 50-75 per cent of the total crop. It is estimated that the plus value was 4s. to 10s. per barrel of 26·4 gallons, with an expense of 5d. per tree. From amongst several the case of a Virginia orchard is quoted of which one-third was subjected to the arsenical treatment, whilst the other two-thirds remained untreated. In the treated portion the amount of healthy fruit exceeded by 50 per cent that of the untreated portion, and by 100 per cent as regards market value. The loss suffered under this heading by the two-thirds of the orchard untreated was valued at £500. These figures so eloquent plead in favour of this simple, economical, and efficient treatment which will meet one day in France with the same success which it already has in America and Norway.

Use against Injurious Fungi.—*Fusicladium dentriticum*, Fuckel (apple scab).—By treating apple-trees with emerald green, against injurious insects, apple scab is, likewise, and to a great extent, diminished. Goff obtained 50 per cent of immaculate apples against 30 per cent on untreated trees with four sprayings of 0·06 per cent bouillie of emerald green neutralized by milk of lime. Galloway states that 0·05 per cent bouillie with a little lime is superior to all other products.

Phytophthora infestans, De By. (potato disease).—Galloway greatly recommends to combat simultaneously both the potato disease and the Colorado beetle a bouillie consisting of 1,00 litres of bouillie bordelaise with 4-10 grammes of emerald green (that is, 4-10 parts of emerald green by weight to 100,000 parts by measure).

Use against Injurious Insects.—The injurious insects combated in America by this process are very numerous, and will now be enumerated, describing only those which ravage European plants and those of America which are of particular interest, because they may eventually prove dangerous to our crops.

Anthonomus Pomorum (apple weevil).—The cleaning of the trunk of the tree and its branches and coating with lime bouillie bordelaise or with acidified green vitriol are treatments capable of destroying the insect in its winter shelter. Spraying with copper arsenite a little before flowering and during the summer may poison and destroy the adult insects which escape the winter treatment. The results of this method are perfect (Debray). Goethe does not share this opinion.

Anthonomus Grandis, Boh. (cotton weevil).—F. W. Maly advises spraying with copper arsenite bouillie to destroy this weevil, the larvæ of which and the perfect insects destroy the cotton flowers.

Zabbrus Gibbus, F. (Zabre bossu).—An arsenical spraying at the right time kills these larvæ.

Crioceris Asparagi (the asparagus beetle).—Vivien recommends for the destruction of the perfect insects and their larvæ sprayings with a bouillie prepared thus: Mix a solution of 2 lb. of blue vitriol in 8 gallons of water with 0·4 gallon of a concentrated solution of sodium arsenite of 15° B.; then add the requisite amount of carbonate of soda to alkaline reaction (it takes about ½ lb.); then it is again acidulated

whilst adding $\frac{1}{20}$ of a lb. of blue vitriol. The bouillie is made up to 10 gallons.

Altises.—These multiple generations of small voracious insects, numerous species of which exist, may be combated by copper arsenites in powder or bouillie.

Haltica ampelophaga, Guer. (altise of the vine, vine louse, *Pucerotte*).—Gaillot's bouillie, the composition of which is given under the heading "Arsenite of Copper" (p. 276), and which is nothing but a bouillie bordelaise containing a little Scheele's green, must be used in this case, yet the same result is obtained by simply adding emerald green to a cupric bouillie.

Psylliodes affinis, Payk. (altise of the potato).—As an efficient method of destroying fungi spores and insects, such as the dryophora and the altise of the potato, Woods recommends bouillies consisting of a mixture of 120 parts of emerald green in 1000 parts of bouillie bordelaise, or 120 parts of emerald green and 750 parts of lime in 100 parts of water.

Haltica Chalybea (plum altise).—Britton states that arsenical bouillies destroy this altise. The perfect insects are destroyed by 0·2 per cent and the larvæ by a 0·06 per cent bouillie.

Cassida nebulosa.—In Saxony the arsenical bouillie has proved itself more efficient than such insecticides as soapy emulsions of petroleum, vinegar, slaked lime in powder.

Silpha, L.—Opaque silph of the beet.

Silpha atrata (black silph).—Silphs like the dryophora of the potato are killed by cupro-arsenical bouillies with an emerald green or Scheele's green basis.

Treatment by Powders.—An intimate mixture of 1 kilogramme (2·2 lb.) in 100 kilogrammes (220 lb.) of very finely divided gypsum, damaged flour, ashes, or a mixture of these different substances, is spread by hand on the dew-charged leaves. This dose suffices for 1 hectare ($2\frac{1}{2}$ acres). The operator must so manœuvre as to have the wind behind him.

Treatment with Bouillies.—There is distributed, preferably by the spraying machine "Eclair," a bouillie of 0·2-0·24 per cent of Scheele's green, or 0·5 per cent of lime and 0·2 per cent of emerald green. Four hectolitres of bouillie per hectare are applied, say 35 gallons per acre. Gaillot's bouillie has been tried with success in the North of France, and in Herault the larvæ die in twenty-four hours. Sorauer advises the use of a bouillie of 1 per cent Scheele's green and 0·2 per cent of flour. Grosjean, Debray, and Hollrung have aided in popularizing this efficient method.

Leptinotarsa decemlineata (Colorado beetle).—In America cupro-arsenical bouillies have been used with success for many years against this voracious insect. This treatment has the advantage of destroying many other insects at the same time and of protecting the plant against potato disease, *Phytophthora infestans*, De By.

Galeruca calmariensis (galeruque of the elm).—In the U.S.A. arsenical bouillies are used to destroy the larvæ of this *chrysomelide*, which rapidly causes the death of the finest avenue trees. But

gigantic spraying machines and powerful pumps mounted on trucks are required, capable of throwing a jet to the top of the tallest trees.

Epilachna or *Coccinella globosa*, Ill., is destroyed by spraying emerald green in powder on the plants (Sajo). Likewise—

Agriotes lineatus, L. (wire-worm); *Entomoscelis adonidis*, Pall.

Weevils.—Stift advises spraying the ravaged plants.

Scolytes.—Fletcher advises coating the tree with oil paint containing emerald green.

Chaetocnema tibialis, Ill.—This altise, injurious to beets in Hungary, may be destroyed by 0·185 per cent emerald green (Gémési).

Cleonus sulcirostris, L.—This beetle, injurious to beets, may be overcome by 0·5-2 per cent emerald green bouillie. The first spraying ought to be done as soon as the leaves appear, the second at the time the insects copulate, say near end of May.

Solenopsis geminatus.—This ant, which does much damage to the young shoots of peach and plum trees, may be combated by spraying with bouillie bordelaise containing 0·05 per cent of emerald green and 4·5 per cent of molasses.

The larvæ of the *Tenthredos* (saw-flies) are successfully overcome by cupro-arsenical bouillies.

Nematus Ribis, Scop. (gooseberry saw-fly).—This insect is successfully overcome in Canada, likewise *N. Pallidiventris.*

Eriocampa adumbrata (cherry-tree saw-fly).—Coquillet successfully used a cupro-arsenical bouillie rendered adherent by the addition of pine resin dissolved in potash.

It is easy to destroy caterpillars by spraying with cupro-arsenical bouillie, for these insects are then the victims of their voracity. The butterflies most injurious to arboriculture which have been treated most successfully belong to the Tortricides, to the Pyralides, and to the Tineides.

Carpocapsa pomonella (coldlin moth).—The damage caused by this pyralis is considerable. Action must be taken to destroy it very soon after the hatching of the caterpillar, for it lives on the leaves until the apples are big enough to be penetrated. The first spraying should be made after the fall of the flower, and the second a week later, before the calyx is re-closed and the fruit reversed on the stem. Spraying during flowering must be avoided, for it would destroy the insects which fertilize the flowers, and render the latter barren.[1]

Carpocapsa funebrana (pyralis of the plum-tree).—Spraying with cupro-arsenical bouillie made at the moment of the fall of the corolla of the flowers and on the young tied fruit poisons the grubs before they can pierce inside the fruit.

Hyponomeuta malinella, Jell (small ermine moth of the apple-tree).—Emerald green sprayings are in general use in certain countries.

Agrotis segetum (common dart moth).—To prevent the damage caused by this voracious grub, which is called the grey-worm, it suffices to make a cupro-arsenical spraying on the young spring shoots threatened. It is not a case of beet crops alone which have been pro-

[1] *Translator's Note.*—Spraying during flowering courts risk of enclosing poison in core of apple.

tected in the North of France and in Herault, but also the gardens which in the spring time suffer much from the hibernating caterpillars of the *Noctua* which attach themselves to the young shoots, and cut the stems of small plants. They escape search and sight, because they hide during the day, and only commit their ravages at night. Fletcher, the Canadian Government entomologist, advises for the destruction of grey-worm the use of a mixture of bran and emerald green. The wheat bran which is used in the mixture is previously moistened and sugared, then spread between the rows of transplanted plants. As soon as the poison is on the soil, the plants are not attacked by the grubs, which take themselves off rapidly, or die of eating it.

Cheimatobia brumata, L. (winter moth, Evesham moth).—The grub of this butterfly, which is particularly injurious in the spring to the buds of apple-trees, pear-trees and plum-trees, is overcome by cupro-arsenical bouillies sprayed on the buds and the young shoots. This process used for a long time in America, and recommended by Riley, has been popularized in France by Prof. Debray of Alger, and Grosjean, inspector-general of agricultural education.

Pieris Rapæ, L., *Pieris Brassicæ* (white cabbage butterfly).—Cupro-arsenical bouillie, spread on the cabbages, is generally used to destroy the caterpillars. The rains suffice to wash the cabbages and render them fit for food.

Hadena Brassicæ (noctua of the cabbage).—A mixture of gypsum and emerald green dusted on the cabbages gives good results.

Leucania Unipunctata, Haw.—Fletcher advises to sprinkle meadows with a mixture of 1 lb. of emerald green and 25 lb. of farina.

Acari.—Amongst the phytoptides may be quoted *Eriophyes Ribis*, Nal., or *Phytoptus Ribis*. In America it is overcome by spraying with 0·06 per cent emerald green, 0·12 per cent of wheat starch or soft soap. The first spraying is made in spring, the second in autumn shortly after the fall of the leaf to prevent the acari from taking shelter in the buds.

97. Copper Arsenite, $Cu_2As_2O_5$.—**Preparation.**—By precipitating a solution of arsenite of soda by a solution of blue vitriol. The green precipitate which forms, filtered, washed and dried, is known as *Scheele's green*. To prepare an insecticidal and anticryptogamic bouillie Gaillot recommends to dissolve 1 lb. of white arsenic and 1 lb. of soda ash in a gallon of boiling water and then to add with constant stirring a solution of 10 lb. of blue vitriol in 10 gallons of water. There is then added a milk of lime, made from 10 lb. of lime and 10 gallons of water, then a solution of 20 lb. of molasses in 2 gallons of water; the whole is then diluted to make 100 gallons of bouillie which is nothing less than a bouillie bordelaise containing a little Scheele's green.

Properties.—Scheele's green is insoluble in water; when it is freshly prepared the precipitate is so fine that it remains a long time suspended in the liquor, which is not the case with the dry commercial product.

Use.—It is used under the same conditions as emerald green.

98. Silicate of Copper, $CuSiO_3$.—**Preparation.**—Dissolve 4 lb. of blue vitriol in 50 gallons of water, and add after cooling whilst stirring a solution of $12\frac{1}{4}$ lb. of silicate of soda in 50 gallons of water. A gelatinous precipitate, insoluble in water, is formed.

Properties.—Copper silicate was prepared by Fairchild, with the object of obtaining a more adherent cupric bouillie than bouillie bordelaise. He, however, found, contrary to his expectations, that this bouillie did not adhere so well as normal bouillie bordelaise. Copper silicate, less soluble than copper hydrate, cannot perform the same services as the latter, and although the silicate of soda used in its preparation is endowed with antiseptic properties, the insoluble product which it forms with copper is, owing to its insolubility, an inert body.

Use.—Fairchild used the silicate of copper bouillie against *Entomosporium maculatum*, Lev. (leaf scald of the pear-tree), and found that it did not damage the leaves of the tree. That is not surprising, as only soluble cupric salts and their derivatives are poisonous to plants.

99. Carbonate of Copper, $CuCO_3$ (bouillie bourguignonne).—**Preparation.**—By adding a solution of a copper salt to a solution of carbonate of soda. To convert 1 kilogramme of blue vitriol, $CuSO_45H_2O$, into carbonate of copper, it requires theoretically 453 grammes of dry sodium carbonate or 1146 grammes of soda crystals, $Na_2CO_310H_2O$.

$$\underset{\text{Copper sulphate.}}{CuSO_4} + \underset{\text{Sodium carbonate.}}{Na_2CO_3} = \underset{\text{Sodium sulphate.}}{Na_2SO_4} + \underset{\text{Copper carbonate.}}{CuCO_3}$$

The bouillie bourguignonne designed by Masson to overcome parisitic fungi is merely carbonate of copper suspended in a given amount of liquid. It is prepared thus: (1) Dissolve 20 lb. of blue vitriol in 5-6 gallons of hot water, and add thereto after cooling a solution of $8\frac{3}{4}$-9 lb. of soda ash or 23 lb. of soda crystals, and dilute the whole to 100 gallons with water. (2) Dissolve each compound in 50 gallons of water and mix the solutions as cold as possible at the time of use. The second bouillie is better than the first. To obtain a quite neutral bouillie soda ash must be used, for soda crystals, which normally contain 62·8 per cent of water, are efflorescent, and a neutral bouillie cannot be prepared from them without groping in the dark. Moreover, they always contain larger or smaller quantities of sulphate of soda. The limpid liquid which separates from the blue precipitate after the bouillie has settled should neither be acid nor alkaline; if blue litmus paper dipped in the liquid turns red, carbonate of soda must be added; if red litmus paper turns blue, blue vitriol must be added.

Properties.—Carbonate of copper is insoluble in water but soluble in organic acids. The deposit formed on the leaves by spraying with bouillie bourguignonne may become soluble as the cupric hydrate of the bouillie bordelaise and eau celeste, or by the juices transpired

by plants, or by water containing carbonate of ammonia or carbonic acid. The amount dissolved being very small, the plant is never in contact with a poisonous amount of soluble copper salt, and bouillie bourguignonne does not burn, except when prepared with a great excess, or with an insufficient amount of carbonate of soda. In making bouillie bourguignonne, not more than 2 kilogrammes of blue vitriol should be used. This quantity is already very strong, and as was the case in other bouillies it has been reduced in modern bouillie bourguignonne to 0·3 per cent. Carbonate of copper freshly prepared by mixing cold solutions of the ingredients is gelatinous, and it is preferably in this form that it should be spread on the leaves to get the maximum adherence and produce the best effect; as it does not preserve this gelatinous condition long, the bouillie must be used immediately after it is made. In fact after eight to ten hours copper carbonate becomes granular, and ends by being converted into a heavy, sandy precipitate, and thus the bouillie loses a portion of its good qualities. This conversion would appear to be accelerated by an excess of carbonate of soda. It already happens when 2·6 kilogrammes of soda crystals are used for 2 kilogrammes of blue vitriol, whilst with 2·3 kilograms, the theoretical amount required, this conversion does not occur until after twenty-four hours. Many bouillies are thus intentionally made with a small excess of blue vitriol, which cannot injure the plant, and which strengthens slightly its action on fungi. If bouillie bourguignonne be made hot, the resulting carbonate of copper is granular and crystalline. Its anti-cryptogamic action is perceptibly inferior to that of gelatinous copper carbonate. A bouillie is often used prepared with 0·4 per cent of blue vitriol and 0·4 per cent of soda crystals, or even 0·3 per cent of blue vitriol with the same amount of soda crystals. Commercial copper carbonate always granular, though excellent to prepare modified eau celeste, is unsuitable for the preparation of a normal bouillie bourguignonne. If nevertheless it is to be used, it must first of all be reduced to the state of paste by means of a little water, adding thereto whilst stirring the rest of the water, keeping the bouillie generally more concentrated than those obtained by precipitation from blue vitriol. The adherence of this bouillie is much less than that of bouillie bourguignonne prepared from blue vitriol. Gerard, Muyssen, and Leplæ consider gelatinous carbonate of copper adheres better than cupric hydrate, and the duration of the action longer than that of bouillie bordelaise. This difference was especially marked when the bouillie bordelaise contained a great excess of lime. However the adherence of a neutral bouillie bordelaise may now be considered as great as that of a normal bouillie bourguignonne.

Use.—Its ready preparation, its uniform composition, its good adherence, its great fluidity not obstructing the spraying machines, have greatly helped to popularize Masson's bouillie, and it has met with a general reception, especially in Germany and in America. It may be used with an equal blue vitriol content, wherever bouillie bordelaise gives good results. It is especially recommended in certain cases. Weiss regards it as superior in the disinfection of purchased

onions and tubers, which by steeping for one to two hours in a 1 per cent bouillie are disinfected. A twenty-four hours' steep does not injure them. Fairchild points out the remarkable results obtained in the struggle against *Entomosporium maculatum*, Lev. (leaf scald of the pear-tree). Its action is surprising on the larvæ of the gooseberry saw-fly (*Nematus ribis*, Scop). To destroy it as soon as the false caterpillar appears, a spray is applied of 2·5 per cent of blue vitriol and 2·5 per cent of carbonate of soda. In less than an hour the larvæ die, blacken, fall, and its ravages are stopped.

100. Bouillie Bordelaise Celeste.—This bouillie is a mixture of insoluble copper carbonate and soluble bicarbonate.

Preparation.—Dissolve 1 kilogram of blue vitriol in a few litres of hot water, and add after cooling 870 grammes of carbonate of soda, then dilute to 100 litres. A proportion of 90 per cent of copper is precipitated as insoluble carbonate, and the remaining 10 per cent of copper is converted into soluble bicarbonate. This small amount of dissolved copper is not enough to cause the bouillie to burn the trees, but it suffices to impart to the bouillie the anticryptogamic properties of eau celeste. Bouillie bordelaise celeste, recommended by Fery, combines the properties of the anticryptogamic bouillie bourguignonne and eau celeste. It is one of the best anticryptogamic bouillies.

101. Basic Acetate of Copper.—Definition.—Commercial verdigris consists largely of basic acetate of copper.

Preparation.—The verdigris industry is localized in the South of France. *Le Verdet extra sec en grains*, of interest here, because of its more uniform composition, is made throughout the whole of Lower Languedoc as follows. The method of manufacture consists in corroding sheet copper by the acid marc of grapes. The marc is chosen as rich in alcohol as possible. It is preserved before use in vats, where it is strongly compressed without access of air. The sheets of copper used weigh about 100 grammes (say $3\frac{1}{2}$ oz.), are 6 centimetres (say $2\frac{1}{2}$ inches) wide, 16 centimetres (say $6\frac{1}{2}$ inches) long, and 1 millimetre ($\frac{1}{25}$ inch) thick. When the marc is to be used, it is taken from the vats and air admitted to convert the alcohol into vinegar or acetic acid. The fermentation which ensues raises the heat to 40° C. (104° F.). When the alcohol of the marc is converted into acetic acid, a little vinegar is added to strengthen its action if it be insufficient, then it is put in contact with copper. New copper with a smooth surface only being attacked difficultly, the sheets undergo a preparation which consists in rubbing them with a pad dipped in verdigris acidulated with vinegar. After drying them in the sun, they are submitted to a temperature of 60°-70° C., which greatly facilitates the first attack. They are then brought quite hot and arranged in layers on the marc, spread out on the ground of a special spot; a layer of marc is spread on them, a fresh layer of copper sheets, and so on until the mass rises 1 metre above the ground. Under the influence of the heat the acetic acid attacks the copper sheets. After six to eight days the marc bleaches; it is exhausted. The green layer formed on the plates is not yet verdigris. To finish the operation the plates

are laid on supports in a stove heated to 30° C. After twenty-four hours the supports are dipped into water at 30° C. (86° F.), where they remain four to five days. This steeping is repeated five to six times. The green crust of verdigris has then dissolved the copper and formed a blue mass of basic acetate of copper. It suffices to scrape this crust, which is commercial verdigris. It comes to market in two forms: (1) As a product containing no moisture, and termed *Verdet gris extra sec*, containing 34-35 per cent of copper. (2) As a still moist product, containing 25-42 per cent of water, and termed *Verdet gris sec merchand*. The latter being of variable composition, and as buyers must have a definite product, it is the *Verdet gris extra sec* which is used in the preparation of the bouillie. It is sold as balls, cakes, or grains. To prepare the bouillie, it suffices to crush the verdigris, mix it with a little water, macerate it for some days, and then dilute it to a suitable consistency.

Properties.—Verdigris is amorphous. But it swells in a little water after a few hours; forming a viscous paste beaten up with much water dibasic acetate of copper splits up into soluble copper acetate and insoluble cupric hydrate, which forms a blue flaky precipitate with the properties of bouillie bordelaise. Bencker believes this precipitate remains flaky for a longer time, and thus keeps itself suspended longer than bouillie bordelaise. The verdigris bouillie has the properties of bouillie bordelaise and blue vitriol. The deposit of hydrated oxide of copper which it contains covers the leaf with a protective layer of insoluble copper oxide, and the solution of copper acetate acts like solutions of all soluble copper salts in an immediate and very energetic manner on the spores of fungi as well as on the plant itself. This soluble portion of the verdigris copper acetate would in fact produce burns if care were not taken to use sufficiently dilute bouillies. Now the dose of soluble copper acetate present in a verdigris bouillie is not sufficient in most cases to corrode the organs touched by spraying, and plants suffer comparatively little by this treatment. However, plants sensitive to dilute solutions of blue vitriol and to cupric hydrate deposited on the surface of their leaves will, after spraying with this bouillie, be poisoned to the same extent and suffer the same damage, followed by partial and even total fall of the leaves, as is the case with ordinary peaches and certain species of rose bushes. Bencker, Girard, Chuard, and Porchet found that the adherence of the cupric hydrate of the verdigris bouillie is superior to that of other bouillies. It must not be forgotten, however, that the cupric hydrates behave in the same manner in all bouillies if these are prepared and used rationally. If bouillie bordelaise formerly adhered badly, compared with bouillies with a verdigris basis, it is not the case now with bouillie bordelaise used immediately after its preparation. A neutral bouillie bordelaise, a bouillie bordelaise celeste, *eau celeste modifiée*, verdigris bouillie, and Perret's bouillie have many analogies to each other. Their adherence, so to speak, is the same, and their anticryptogamic energy almost identical. Careful study of this point has shown that the tendency of copper salts to poison plants as well as their anticryptogamic energy is perceptibly proportionate to their copper content. The action is inversely pro-

portional to the molecular weight of the copper compound contained in a given amount of liquid, and the rapidity of the action is proportional to the degree of solubility of the copper compound. The weak acid or alkaline reaction of these preparations has no secondary curative effect. Verdigris bouillie must, therefore, be prepared with a weaker dose of verdigris than that of the blue vitriol, which enters into the composition of bouillie bordelaise, firstly because blue vitriol only contains 25 per cent of metallic copper, whilst verdigris contains 35 per cent; secondly because verdigris is partially soluble in water. The dose of 1·5 per cent is not exceeded in bouillies, it is mostly lower than this and descends to 0·1 per cent. Verdigris bouillie has the same drawback as blue vitriol and eau celeste. It leaves no visible mark on the plants, and renders the control of the work of the operator difficult. To obviate this drawback, Chuard and Porchet add potter's clay, china clay, carbonate of magnesia, gypsum, or chalk. It is, moreover, comparatively dearer than other copper preparations of equal copper content, which is an obstacle to its becoming popular.

Use.—Verdigris has been used as an anticryptogamic in France since 1890, and in America since 1892.

Peronospora viticola, De By. (mildew of the grape).—In virtue of the energy and adherence of verdigris, three treatments suffice (Bencker). The first fifteen days to three weeks after the issue of the first leaves with a 1·5 per cent bouillie, 2 hectolitres per hectare (17·6 gallons per acre) suffice. If the invasion of mildew be very great, supplementary treatments with 0·35 per cent of verdigris are required. Cuboni advocates this treatment.

Guignardia Bidwelli, V. and R. (black rot of grapes).—Galloway with six sprayings with 0·1 per cent verdigris bouillie obtained 90·47 per cent of sound grapes against 19·06 per cent on untreated vines. According to experiments by Rathay and Havelka, the spores of *Guignardia* are killed after twenty minutes by steeping in 0·5 per cent bouillie. Linhart got the same results with copper acetate. Rougier recommends Viala and Pacottet's bouillie consisting of neutral copper acetate 1 lb., acetic acid 8 fluid oz., water 10 gallons.

Puccinia (rust).—Galloway got interesting results by spraying a field of grain four times, on 6, 16, and 25 June, and 5 July; with a 0·3 per cent bouillie he entirely prevented rust. The uredospores of *Puccinia coronata* were prevented from germinating by 1·0 per cent bouillie (Hitchcock and Carleton).

Entomosporium maculatum, Lev. (leaf scald of the pear-tree).—Halsted found that 0·2 per cent bouillie suffices to overcome this parasite, and Fairchild advocates verdigris as the best preparation against spots of the leaves of the pear-tree.

Phytophthora infestans, De By. (potato disease).—Whilst Pearson found verdigris as energetic as bouillie bordelaise, Sturgis found it without action on *Phytophthora Phaseoli* (Lima bean mildew).

Rot of Grapes.—Consecutive attacks of *Cochylis*. These are prevented, according to Vermorel, if the grapes are sprayed with verdigris.

102. Copper Acetate, $Cu(C_2H_3O_2)^2H_2O$.—**Preparation.**—Neutral copper acetate, or crystallized verdigris, is obtained: (1) By treating

copper turnings by acetic acid until complete solution is effected. (2) By double decomposition between blue vitriol and lead acetate.

$$\underset{\text{Copper sulphate.}}{CuSO_4} + \underset{\text{Lead acetate.}}{Pb(C_2H_3O_2)^2} = \underset{\text{Copper acetate.}}{Cu(C_2H_3O_2)^2} + \underset{\text{Lead sulphate.}}{PbSO_4}$$

Properties.—Copper acetate forms greenish-blue crystals with a molecule of water of crystallization. These crystals contain 31 per cent of metallic copper. They are completely soluble in five times their weight of boiling water at 15° C. Used to overcome cryptogamic diseases copper acetate behaves like blue vitriol, and in general, like all soluble copper salts, that is to say, it is poisonous to plants, whilst at the same time it acts very energetically on parasitic fungi. However, this action is ephemeral, because cupric acetate decomposes on the surface of the leaves into a basic acetate behaving like copper hydrate. Used in Italy at 1 per cent against *Leaf Curl of Peach* it caused, like all other copper preparations, the total fall of the leaves and the fruit treated (Brioni). A 0·5 per cent solution of cupric acetate destroys the germinative power of the spores of *Guignardia Bidwelli* in twenty minutes, whilst 0·5 per cent of blue vitriol takes thirty minutes to produce this effect. Its action on the spores of this fungi is therefore relatively identical with that of blue vitriol, for copper acetate contains 31 per cent of metallic copper, whilst blue vitriol only contains 25 per cent. The action of copper acetate lasts longer than that of blue vitriol. Chuard and Duserre found that this was due to the neutral acetate being converted on the leaves into an insoluble, very adherent derivative.

Use.—Copper acetate has been used in Italy and Switzerland especially against mildew, *Peronospora viticola*, De By., in 0·5-0·8 per cent doses. It is sometimes used in France in the last treatment of the vine, so as not to soil the grapes, and avoid introducing sulphuric acid into the wort or any other substance capable of changing the quality of the wine. Copper acetate is, so to speak, abandoned to-day and replaced by the copper bouillies in the struggle against parasitic fungi, for it has no advantage over the latter preparations and it is a little more costly in use.

102a. Perret's Bouillie is a bouillie bordelaise containing a portion of its hydrated oxide of copper in solution as cupric saccharate.

Preparation.—By mixing, in a certain order, a solution of blue vitriol and sugar with milk of lime. Perret, the inventor, prepares it as follows: Beat up 20 lb. of quicklime after slaking with 80 gallons of water, and whilst stirring constantly add this milk of lime to 1 lb. of sugar in 10 gallons of water; then run this mixture of lime and saccharate of lime into a solution of 20 lb. of blue vitriol in 100 gallons of water. It is essential that the copper solution be cold. Prillieux advises that care be taken to see that the bouillie is slightly alkaline. Barth, in 1896, advised the preparation of cupric saccharate bouillie thus: Dissolve 20 lb. of blue vitriol in 40 gallons of water, and after cooling run in a solution of 3 lb. of sugar or 5 lb. of 50 per cent molasses in 30 gallons of water, then a milk of lime with 1½ lb. of

quicklime or 2 kilograms of slaked lime and 30 gallons of water. The necessary dose of sugar may also be added to the bouillie bordelaise. The action of bouillies of this composition is excellent. Later on, the addition of more sugar was advocated. Peglion proposed $\frac{3}{4}$ lb. for $1\frac{1}{2}$ lb. of blue vitriol and Petermann 4 lb. of molasses for 2 lb. of blue vitriol and 4 lb. of lime. The increase in the sugar must be regarded as injurious to the quality of the bouillie, and it throws discredit on a preparation which, after this change in its composition, lost the masterly qualities imparted to it by Perret and Barth. The amount of copper may be brought to the proportions now used in bouillie bordelaise, say 0·5-1 per cent of blue vitriol, but the dose of sugar, which should never exceed 15 per cent of the blue vitriol used, must also be reduced. Perret's bouillie is a bluish-green liquor with cupric hydrate and sulphate of lime in suspension. The sugar which enters into the bouillie prepared by Perret's and by Barth's processes is not enough to convert the whole of the blue vitriol used into saccharate. The 1-3 lb. added to the bouillie cannot convert more than 1·4-4·2 lb. of blue vitriol into saccharate. The saccharated bouillie contains, therefore, 0·14-0·42 per cent of soluble copper. Perret remarked that by adding sugar to bouillie bordelaise it became more adherent to the leaves than simple bouillie bordelaise, and that its anticryptogamic action was increased owing to the soluble copper salts which it contained.

Barth was the most zealous advocate of this bouillie which he regarded as the best, as the ideal bouillie. It never burned the leaves, and its adherence was surprisingly perfect. This last property was due to the cupric saccharate being assimilated without injury by the plant, which would so far render it immune to cryptogamic diseases. This opinion has been greatly disputed. It has been shown besides that the plant had no need to absorb large amounts of soluble copper derivatives, but on the contrary, the strong doses absorbed after the use of soluble copper salts always injures the health of the plant. Infinitesimal doses of copper suffice to give to the plant greater resistance against parasitic fungi, and if that infinitesimal amount is not directly assimilable, it is rendered so by the juices transpired by the leaves. It is possible, however, that cupric saccharate, an organic derivative of copper, may be directly assimilable by the plant, and that this property may be such as to give it a plus value as a stimulating bouillie. This bouillie, however, cannot have a superior anticryptogamic action to other bouillies, for a bouillie can never act as a destructive agent of the organs of fungi which are distributed in the interior of plants. Its object is to damage the exterior organs of fructification, annihilate the spores, and prevent their dissemination. This end is perfectly attained by bouillie bordelaise. Perret's bouillie was a great improvement on the primitive bouillie bordelaise, when the latter had not the energy nor the adherence of the present bouillies, owing to defects in its composition. But Perret's bouillie now is perceptibly the same as bouillie bordelaise, or such preparations as verdigris bouillies, which along with cupric hydrate contain a certain amount of soluble copper. Girard, agreeing with Gindt and Sendersens, regards Perret's bouillie

as being more adherent. Other observers declare the contrary, but it has been generally observed that Perret's bouillie communicates a greener tint to the foliage and a more prolonged one than other bouillies. Galloway advocates adding to bouillie bourguignonne a certain dose of sugar, and has used with success a mixture of blue vitriol 3 lb., soda crystals $3\frac{1}{2}$ lb., molasses 3 lb. in 10 gallons of water. Whilst causing burns on the leaves of the vine this bouillie, used against black rot, brought the percentage of sound grapes from 46 per cent on the untreated vines to 98·51 per cent. For a sucrated bouillie not to cause burns, the amounts of sugar indicated by Perret and by Barth should not be appreciably exceeded, for with larger doses of sugar the whole of the copper is transformed into soluble cupric saccharate which behaves like solutions of copper acetate. Bee-keepers have protested against the use of Perret's bouillie, under the pretext that bees by collecting copper saccharate on the surface of the treated leaves are poisoned, and may convey into the honey an element injurious to human health. It took long and careful experiments by E. Jacky in 1900 to prove the want of foundation of their complaints, and to demonstrate that if bees are very fond of sugar and molasses, they shun and do not absorb these sweets when they contain copper.

Use.—After a general infatuation for Perret's bouillie, at the time when Michel Perret recommended it as a substitute for bouillie bordelaise, which then possessed many defects, this preparation fell into oblivion. The chief reason, as pointed out by Dr. Cazeneuve, is that the composition of the bouillie bordelaise has been so modified that as far as its action is concerned it cannot be compared with the primitive bouillie. By substituting molasses for sugar and by greatly increasing the dose, Perret's bouillie has been converted into a solution of cupric saccharate. As this bouillie contains large quantities of soluble copper, its contact with the plant becomes deadly to it. Its adherence is less and it does not stand rain. Perret's bouillie may be used in all cases where bouillie bordelaise gives good results. However, Barth found it superior in the struggle against mildew. Nijpels found it better against *Phytophthora infestans*, De By., when applied in two sprayings annually. Sorauer prefers it against *Asteroma radiosum*, Fr., of the rose-bush and to prevent the fall of the leaves of this shrub, due to the parasiticism of a rust known as *Phragmidium subcorticum*, Wint.

Against *Alternaria Brassicæ f. nigrescens*, Pegl. (roasting of the leaves of the melon) it is better than bouillie bordelaise and it appears to act on *Botrytis cinerea*, Pers. [*Sclerotina Fuckeliana*, De By.] (grey rot of the vine) (Nijpels).

102b. Various Bouillies.—As soon as the active principle of the cupric bouillies was definitively established efforts were made to fix the cupric hydrate and copper carbonate which they contain in a more durable manner on the leaves. Everything which cements and binds was incorporated therein, milk, albumen, glue, soaps, oils, and resins. However, the action of these binders on copper derivatives is not, as may be supposed, purely mechanical. These substances often act chemically. Most of them form insoluble derivatives with copper,

capable, it is true, if they are used immediately after their preparation, of depositing on the leaves a copper pellicle, a true varnish which will resist the weather indefinitely. But the thin pellicle which covers the leaf may in the end, as shown by Galloway, stop the physiological functions of the organs covered and injure the normal evolution of the plant; and these copper derivatives, insoluble in the atmospheric agents as well as in the exudation of plants, have lost, if not all, at least the greater part of their anticryptogamic power. Under such conditions they cannot, therefore, form like cupric hydrate an insuperable barrier to the spores deposited on the leaves. Parasitic fungi are very often seen to develop normally on leaves and fruit covered with a layer of these copper varnishes. The effect of the greater part of these new bouillies is, therefore, quite illusory. However, their quality depends greatly on their composition. When the amount of binders prescribed to render a bouillie adherent are not sufficient to convert the whole of the cupric hydrate into an insoluble binding organic derivative, that bouillie still contains the greater part of its copper under the active form of cupric hydrate which maintains its good anticryptogamic properties. The binders so used may encircle the active principles of the bouillie and retain them on the leaves and so become useful. Trials of comparative adherence made with bouillies normally and freshly prepared, and thus at the moment when their adherence is at a maximum, have not always given results in favour of the new bouillies. The advantage of using binders in the bouillies may be regarded as problematical, for the simple bouillies now used show the same tenacity which may be regarded as sufficient. Still more so than in the case of ordinary bouillies is it necessary to use these bouillies immediately after preparation, for the fine, flaky, organic precipitates which they contain in the beginning agglomerate and resinify, rapidly encrusting the machines and preventing a uniform distribution of the bouillie on the plants. Finally, the binders used in these bouillies may injure the organoleptic properties of the wine. It has been observed after their use that the wine left something to be desired, and the conviction was formed that it was these substances which passed into the wine and profoundly altered its gustative properties.

103. Albuminous Bouillies.—Preparation.—By adding to a solution of blue vitriol bouillie bordelaise or bouillie bourguignonne a sufficiency of an albuminous body to convert all the copper into copper albuminate.

104. Lactocupric Bouillie (Crouzel's).—**Preparation.**—Dissolve 20 lb. of blue vitriol in 10 gallons of water, add 4 gallons of unboiled milk, say about $1\frac{1}{4}$ lb. of casein, stir strongly for five minutes, and run into enough water to make 100 gallons. Skimmed milk does equally well.

Properties.—This bouillie is acid and forms a mixture of blue vitriol and cupric caseate; this latter forms a precipitate insoluble in water, the rôle of which is to retain by encircling them the small crystals of blue vitriol formed by the evaporation of the bouillies on the surface of the leaves. If burns caused by contact of blue vitriol with plants, especially with the proportions given above, be feared, it

suffices to neutralize the acidity with copper carbonate. The bouillie thereby becomes an albuminous bouillie bourguignonne, and contains a mixture of carbonate and caseate of copper. Crouzel regards the acid bouillie as the most active. Caseate of copper is comparatively stable and remains rather long suspended in the liquid as finely divided particles which do not choke up the machines, and can be perfectly distributed over the surface of the plant. Nevertheless, it is necessary to use this bouillie the moment it is prepared.

105. Bouillie Bordelaise Modifiée.—This name is applied to a bouillie to which a little skim milk has been added. Sorauer recommends it against *Uromyces Dianthi*, Niessel (poppy rust). Cazeneuve compared the adherence to the leaves of three albuminous bouillies, which he made thus :—

TABLE LVI.—*Composition in Grammes of Cupro-Albuminous Bouillies.*

	I.	*II.*	*III.*
Blue vitriol	2000	2000	2000
Quicklime	1000	1000	1000
Milk, 2 litres, say casein . . .	60	—	—
Dried white of egg	—	100	—
Dried blood	—	—	100

The blue vitriol was dissolved in 70 litres of water, the lime slaked and beaten up with 20 litres of water and then run into the blue vitriol solution. The milk was diluted with 8 litres of water, and the solution of albumen and prepared blood in 10 litres of water; these solutions were finally run into the preceding mixture. The excess of lime was used to fix the casein and the albumen as caseate and albuminate of lime, and to preserve all its energy to the cupric hydrate of the bouillie. The sprayings were made on 16 August, 1897, some days before floods of rain, after which it was found that the adherence of the lactic bouillie bordelaise was not appreciably better than that of the saccharated bouillie. But the spots produced by the evaporation of the albuminous bouillie lasted to the end of the season. Galloway added a very strong dose of glue to bouillie bourguignonne. The composition of this bouillie was: Blue vitriol 3 lb., soda crystals 3½ lb., glue 3½ lb., water 100 gallons. Adherence was perfect, and the results obtained against black rot were: Untreated, 41·36 per cent of sound grapes; treated with ordinary bouillie bordelaise, 86·47 per cent; treated with the new glue containing bouillie, 100 per cent. Unfortunately the cupric bouillie fixed on the whole surface of the plant so far injured the vegetation that Galloway cannot, in spite of the fine results obtained, recommend this new bouillie in preference to bouillie bourguignonne.

106. Soapy Bouillies.—Attempts have been made to increase the adherence of different bouillies, and even of eau celeste by incorporating soap or oil. Copper salts form with fatty acids derivatives insoluble in water and cold alcohol, but soluble in ether and in amylic

alcohol, and in ethylic alcohol in the hot state. To prepare a copper soap an ammoniacal solution of oil is added to an ammoniacal solution of copper hydrate. Neutralizing the excess of ammonia by acetic acid, an insoluble apple-green precipitate is obtained which agglomerates and resinifies quickly. The same compound is also formed when a soap solution is added to ordinary copper preparations. Swingle was the first in 1895 to add soap to copper bouillies in sufficient quantity to cause them to froth. He observed that these bouillies adhered even on very smooth leaves. Galloway, who experimented at the same time, recommended the following soapy bouillie bordelaise: Blue vitriol 1 lb., quicklime $\frac{1}{2}$ lb., soap 1 lb., in 10 gallons of water. He preferred rosin soaps to fatty soaps. The soap solution is added to the mixture of blue vitriol and lime, and the whole stirred until the froth persists. A soapy bouillie bourguignonne of the following composition is also used in America: Blue vitriol $1\frac{1}{4}$ lb., soda crystals $1\frac{3}{4}$ lb., white soap $\frac{1}{4}$ lb., water 10 gallons. Having observed that the properties of eau celeste were actually increased by a little soap, and recognized that this new preparation is one of the best existing, Fairchild became the advocate of soapy eau celeste. When this bouillie is applied, it forms on the surface of the leaf by evaporation of the ammonia a precipitate of copper with the fatty acid of the soap, which owing to its sticky nature remains a long time adherent, and retains the cupric hydrate. Soapy eau celeste is no longer in this form so corrosive to plants, and does not attack the leaves of fruit trees, vine trees excepted. In America it is prepared as follows: Dissolve 400 grammes of blue vitriol in 50 litres of water, add thereto 20 cubic centimetres of ammonia of 26° B., and finally a solution of 1·25 kilograms of soap in 50 litres of water. In Italy a more ammoniacal eau celeste is used, the composition of which is as follows: Blue vitriol $\frac{1}{2}$ lb., ammonia 16-24 fluid oz., soap 3 lb., in 10 gallons of water. According to Tozetti and Del Quercio, this eau celeste may be used more dilute. In France, Lavergue, Guillon, and Gouirand are the champions of soapy bouillies. They compared a soapy bouillie with the usual bouillies, and classified them as regards adherence thus: (A) *Soapy* bouillie made from 2 per cent blue vitriol and 3 per cent of soap. (B) *Bicarbonate of copper* bouillie made from 2 per cent blue vitriol and 3 per cent of bicarbonate of soda. (C) *Copper carbonate* bouillie made from 2 per cent blue vitriol and 3 per cent of sodium carbonate. (D) Bouillie bordelaise made from 2 per cent blue vitriol and lime to alkaline reaction. Eau celeste made from 2 per cent blue vitriol and ammonia to complete solution. *Verdigris* containing 2 per cent verdigris. (E) *Gelatinous* bouillie. Bouillie bordelaise with 3 per cent gelatine. (F) *Saccharated* bouillie, above bouillie with 1 per cent molasses. (G) Neutral bouillie containing 2 per cent of neutral acetate of copper.

Soapy bouillies being even more injured by keeping than bouillie bourguignonne, all the above-mentioned bouillies were applied immediately after preparation. An old soapy bouillie encrusts the spraying machines. Condeminal advises a bouillie bordelaise to

which linseed oil has been added. This plays no other part than the soap used in soapy bouillie. This bouillie is prepared as follows: Slake 10 lb. of recently burnt fat lime and emulsify therewith $\frac{1}{4}$ lb. of linseed oil, then run this mixture into a solution of 20 lb. of blue vitriol in 50 gallons of water, and make up the bulk with enough water to make 100 gallons. To render these bouillies insecticidal as well as anticryptogamic, petroleum is added. A stable bouillie is prepared as follows: To a soapy bouillie bordelaise of the following composition, blue vitriol 1 lb., lime $\frac{1}{2}$ lb., soft soap 1-3 lb. or rosin soap 7-9 lb., in 10 gallons of water, add 2-6 per cent of a petroleum and soap emulsion, made from petroleum 2 gallons, soap $1\frac{1}{4}$ lb., water 1 gallon. Zacharewitcsh obtained excellent results with a petroleum and soap bouillie against *Fumago salicina* and the *Cycloconium oleaginum* (fumagine of the olive-tree) which invade the olive attacked by *Lecanium oleæ*. The bouillie contained: Soft soap 10 lb., petroleum 4 gallons, blue vitriol 10 lb., in 100 gallons of water.

A concentrated solution of precipitated green copper soap in ether or alcohol applied by the brush on the wounds of trees produced by the woolly aphis covers them after drying with so adherent a cupric pellicle that it forms a very efficacious and durable protection against exterior destructive agents, and lets the wounds heal rapidly. Rain does not remove this coating, which thus persists for many years. Laborde found that Saglio bouillie, containing 3 per cent of a mixture of rosin soap and blue vitriol, used in the struggle against the *Eudemis* and *Cochylis* of the vine, destroys 95 per cent of the first and 80 per cent of the second parasite.

107. Resinous Bouillie.—On the suggestion of Rosenstiel, Perraud recommended in 1898 a resinous bouillie of the following composition: Blue vitriol 1-2 lb., rosin $\frac{1}{2}$ lb., soda crystals to alkaline reaction, in 10 gallons of water. The preparation requires some precautions, for rosin does not dissolve in water, only in hot alkali; 5 lb. of carbonate of soda are dissolved in 2 gallons of water, then, after having brought this solution to the boil, 5 lb. of powdered rosin are added gradually, stirring the mixture till it becomes fluid. This solution of rosin soap is poured after cooling into a solution of 20 lb. of blue vitriol. A solution of carbonate of soda is added to this mixture until the bouillie is alkaline to litmus paper and the bulk made up to 100 gallons. This bouillie much resembles the soapy bouillie bordelaise recommended in 1895 by Galloway, made by adding rosin soap to a 1 per cent bouillie bordelaise. In this same category may be classed the Aleppo pine galipot bouillie, recommended by André and Trabut referred to on p. 214.

Vidal recommends against the fumagine *Capnodium* (black smut) of the olive-tree a bouillie consisting of bouillie bordelaise 100 gallons, spirits of turpentine 1 gallon.

CHAPTER XVII.

MERCURIC CHLORIDE (CORROSIVE SUBLIMATE)—TIN CRYSTALS.

108. **Mercuric Chloride (Corrosive Sublimate),** $HgCl_2$.—**Preparation.**—By [dry] heating an intimate mixture of equal parts of mercuric sulphate and common salt to which a little manganese dioxide has been added.

Properties.—White crystalline powder of which 6·57 grammes are soluble in 100 grammes of water at 10° C., and 53·96 grammes in 100 grammes of water at 100° C. It is slightly soluble in alcohol and very soluble in ether, which extracts it even from its aqueous solutions. The taste of corrosive sublimate is bitter and nauseous. It is a violent poison, which absorbed by the mouth produces considerable inflammation of the mucous membrane, even to the point of destroying it. Corrosive sublimate possesses the property of precipitating albumen; it forms with it mercuric compounds soluble in an excess of albumen and in solutions of common salt. Its powerful antiseptic action results from this affinity for albumen. Corrosive sublimate preparations should be made in glass or earthenware dishes, the metals decomposing it.

Action of Corrosive Sublimate on Plants.—Mercuric chloride acts on plants like blue and green vitriols, but proportionately with greater intensity. If the plant is placed through the roots in contact with a certain dose of corrosive sublimate, it dies. Mouillefert found that this dose for vines planted in 3-litre pots was 2 grammes in 250 cubic centimetres of water; the dose of 0·5 gramme in 250 cubic centimetres of water had no effect on the vine but killed weeds, chiefly *Mercurialis annua, Senecio vulgaris, Sonchus oleratus, Borrago officinalis, Sinapis arvensis, Malva sylvestris,* and *Amarantus blitum.* Trials by Mouillefert to overcome the phylloxera show that corrosive sublimate solutions are absorbed by the roots and poison the juice. Spraying with corrosive sublimate solutions burns the leaves; however, a solution of 0·015 per cent does not injure orange-tree leaves (Coquillet). Mercurial sprayings are deadly to the vine (Leon Vignon and J. Perraud). Dr. Cazeneuve's trials, however, tend to show that corrosive sublimate used in 0·04-0·05 per cent does not hinder the growth of the vine. Like green and blue vitriols an infinitesimal dose of sublimate may stimulate vegetation instead of injuring it. Ono has shown that this dose is 0·0013 per cent for green algæ possessing chlorophyll. The pickling of the seed in a 1-2 per cent bath of corrosive sublimate does not diminish their germinative power. Sturgis found that the seeds of the cotton plant germinate after steeping half an hour in a 1-2 per cent solution of sublimate.

Action on Fungi and their Spores.—Used in a dose lower than 0·0013 per cent corrosive sublimate stimulates, according to trials by Ono, the growth of saprophytic fungi, but at this strength parasitic fungi cannot support it. Hitchcock and Carleton found that the uredospores of *Puccinia coronata* and *Puccinia rubigo vera*, which are the spores of the parasitic fungi most resistant to poisonous salts, were incapable of germinating in a 0·001 solution of corrosive sublimate. There is, according to Wuthrich, a great similarity between the action of corrosive sublimate on the spores of fungi and that of blue and green vitriol. This action is, on the one hand, proportional to the chemical equivalent of these salts, and on the other hand, these proportions adhered to, corrosive sublimate is ten times stronger than blue vitriol and 100 times stronger than green vitriol. The following are the respective doses of these salts required to prevent the germination of the different parasitic fungi :—

TABLE LVII.—*Showing the Dose of Green and of Blue Vitriol and of Corrosive Sublimate Per Cent Required to Prevent the Germination of the Spores of Different Parasitic Fungi.*

Fungi.	*Spores.*	*Germination Nil.*		
		Green Vitriol.	*Blue Vitriol.*	*Mercuric Chloride.*
Phytophthora infestans	Conidia	0·139	0·0125	0·00135
,,	Zoospores	0·139	0·0125	0·00135
Peronospora viticola .	Conidia	0·139	0·0125	0·00135
,,	Zoospores	0·139	0·0125	0·00135
Puccinia graminis .	Uredospores	1·39	0·125	0·01350
,,	Aecidiospores	0·139	0·0125	0·00135
Ustilago carbo . .	Spores	1·39	0·125	0·00135
Claviceps purpurea .	Spores	13·9	0·0125	0 00135

Herzberg submitted the spores of different species of *Ustilago* to the action of corrosive sublimate and found that they all behave in much the same way, with the exception of *Ustilago Jenseni*, which resists a little better. The following are the doses which prevent the germination of the spores examined :—

TABLE LVIII.—*Showing the Dose of Corrosive Sublimate Per Cent Required to Prevent the Germination of Spores of the Various Species of Ustilago.*

	Old Spores.	*Young Spores.*
Ustilago Jenseni .	0·005-0 01	0·005-0 01
,, Avennae .	0·005-0·01	0·001-0·005
,, Perennans	0·001-0·005	0·001 0·005
,, Hordei .	0·005-0·01	0·001-0·005
,, Tritici .	0·005-0·01	0·001-0·005

Action of Corrosive Sublimate on Insects.—Contact with corrosive sublimate, even prolonged, has no action on insects and their eggs; thus the eggs of *Bombyx mori* still hatch after twenty-four hours steeping in a 1 per cent solution. Sublimate is, however, a violent poison; it may enter with the food of the insect into their digestive system.

Use.—*Lichens.*—Waite obtained a negative result with a 1 per cent solution.

Potato Scab, produced by a bacteria, Bolley; *Potato Pox* (Rhizoctinia Solani), Kuhn; *Rot of the Stem of the Potato* (Rhizoctinia), Rolfs.—Bolley found that corrosive sublimate is one of the best substances to disinfect seed potatoes and safely destroy all the bacteria and spores of parasitic fungi on the surface of these tubers. The results obtained controlled by Sturgis, Rolfs, and Woods were excellent. This method, in fact gave 99 per cent of healthy potatoes, whilst the infected potatoes (the untreated) only gave 1-4 per cent, and the tubers treated by bouillie bordelaise, 53-57 per cent. But the effect of this treatment, like that of the others already described, is *nil* if the potatoes are planted in a field already infected and manured with infected dung. The soil should be disinfected previously, or laid down to a different crop for several years. Potatoes are disinfected thus: They are freed from earth and the pellicular membranes surrounding them, then steeped for 1½ hours in a 3 per cent solution of corrosive sublimate. They are then washed, dried for a day, and then planted. Rolfs uses a 0·94 per cent solution. Jones and Morse advise disinfection by immersion for one hour in a 1 per cent steep of corrosive sublimate. Germination is normal even after steeping five hours; after twenty-four hours a certain injury occurs to the germinative capacity.

Bacillus tabificans, Dell.—Bacillus which invades the leaves of the beet and produces jaundice. Delacroix found this bacillus on the seed and obtained sure disinfection by steeping the seeds in a 2 per cent solution of sublimate.

Peronospora viticola, De By. (mildew of the vine).—Corrosive sublimate is, without doubt, a powerful anticryptogamic, which, in the struggle against cryptogamic diseases of the vine, in general, might be of great service if it were not so poisonous, and if it adhered better. Cazeneuve in his trials with a mixture of excelsior verdigris 1 per cent, and of corrosive sublimate 0·04 per cent, and with a solution of mercuric chloride of 0·05 per cent, did not show in the first case any greater categoric action than verdigris alone, but in the second case the action was perfect. On the other hand, Kaserer obtained a perfect result by the use of a solution containing 0·1-0·2 per cent of sublimate and milk of lime. The adherence of the sublimate being very bad, it is necessary to multiply the treatments according to the frequency of the rains if efficient protection of the plant be desired. An addition of 0·5 per cent of starch has been tried to increase the adherence of sublimate solutions. Corrosive sublimate is a very dangerous substance to man, and there is no doubt that it can eventually pass, although in small amount, from the grapes into the vine. Leon Vignon and J. Perraud have estimated the mercury in drawn wine, pressed wine, lees

marc, and grapes from vines treated with mercury salts. It follows from their analyses that grapes and the products of their fermentation only contain traces of mercury, without danger to the consumer. Berthelot followed this note, presented to the Academy of Sciences, by the following remarks: "The effects of the doses of mercury found by the above authors on products consumed daily and in a prolonged manner ought to be regarded as suspicious and dangerous". It is thus prudent and reasonable only to apply the mercurial treatment on such organs of plants as are not consumed, or in winter applications.

Phytophthora infestans, De By. (potato disease).—This disease has been circumscribed by adding corrosive sublimate to the soil. This treatment is, however, too costly.

Ustilagineæ (smut diseases).—Bolley found that the disinfection of seed-corn against *Ustilago Bordeih*, Pers., by corrosive sublimate gave superior results to that done with blue vitriol, formaline, hot water, or potassium sulphide.

Uredineæ (rusts).—Sublimate has been used preventively against the rust of cereals by Hitchcock, Carleton, and Galloway. This substance has given worse results than blue vitriol: a 0·1 per cent solution has little effect, a 0·01 per cent solution is without action.

Fusarium roseum.—Mangin advises to overcome this disease by disinfecting the soil with corrosive sublimate.

Guignardia Bidwelli, V. and R. (black rot of grapes). — The action of corrosive sublimate on the spores of fungi has been compared with that of blue vitriol, and, as has been shown, it is ten times stronger. Some vine-growers have used sublimate in place of cupric bouillies in the treatment of black rot. Cazaux and Quentin declare they have obtained decisive results very superior to those obtained by cupric bouillies. The latter obtained a perfect result on a portion of a vineyard, on a low, wet situation, favourable to the development of cryptogamic diseases, and whose crop it had never been possible to preserve entirely; it even stopped an invasion of black rot in full evolution on the grapes. These vines were treated with four sprayings with a 2 per cent bouillie bordelaise containing 1 per cent of sublimate. The plots treated with pure bouillie bordelaise did not nearly give so good a crop as those treated with the sublimate bouillie. The winter treatment, consisting in coating the stems with a solution of sublimate, is greatly recommended against this formidable disease.

Disinfection of Flower Seeds.—Hiltner advises steeping for two hours in a 0·1-0·2 per cent solution to disinfect flower seed from plantations invaded by this redoubtable fungus, or purchased from outside. This treatment does not injure the germinative capacity of the seed, even if the steeping lasts eight hours.

Use against Insects.—*Conchylis ambignella*, Hubn (cochylis of the vine), *Tortrix vitana* (pyralis of the vine).—Barbut tried with mediocre success solutions of corrosive sublimate to destroy caterpillars of butterflies. It has been remarked, however, that vines treated against cryptogamic diseases by mercurial bouillies no longer suffer from these caterpillars.

Aspidiotus Aurantis (cochineal of the orange-tree).—Destroyed

by spraying trunks and branches with a strong solution of corrosive sublimate.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—Mouillefert showed that it took four hours' contact in a 1 per cent solution to kill this formidable aphis. The oldest insects succumb first, the youngest last. By dipping the extremity of a root covered with adult and young phylloxera into a solution of sublimate, the adults, the sucking proboscis (rostulum) of which sunk in the root continually pumps the juice, die in an hour, whilst the larvæ persist. Used on an infested vine the results were bad. Vines stripped to a depth of 15 centimetres (6 inches) were treated with 20 grammes of mercuric chloride dissolved in 10 litres of water. After a few days the roots examined still contained numerous living phylloxeras. Corrosive sublimate is therefore powerless against this insect, for the physical and chemical forces to which this salt is subjected in the soil soon render it harmless. The same failure attended the attempt to poison the sap by introducing into it 1 gramme of calomel (mercury protochloride) in a hole, made at the base of the stock, which was closed up forthwith (Ponsard's process, 1872). Neither had mercury bisulphide (Catala's process) any action on this aphis.

Schizoneura lanigera (woolly aphis).—The use of corrosive sublimate sprayings in concentrated solution does not destroy this aphis. Thiel found *per contra* that an insecticide consisting of mercurial ointment 1 lb., soft soap 7 lb., petroleum 2 lb., to which alcohol is added at the moment of use, is one of the most active compositions capable of killing all the aphides and of radically curing the apple-trees.

Ants.—Corrosive sublimate is used to poison the bait.

Rodents.—To kill rats, balls are made from a paste of bread-crumbs $12\frac{1}{2}$ oz., butter 6 oz., sublimate or nitrate of mercury 3 oz., placed at the spot frequented by the rodents.

109. Tin Crystals, $SnCl_2$.—**Preparation.**—By dissolving tin in concentrated hydrochloric acid, taking care there is an excess of tin. The liquid heated until it marks 75° B. deposits on cooling the product known as tin crystals.

Properties.—Stannous chloride is very soluble in water. If the solution be diluted it becomes cloudy, depositing an oxychloride, $SnCl_2SnO$; tin crystals are poisonous.

Use.—Sbrozzi tried tin crystals as a substitute for blue vitriol to overcome *Peronospora viticola*, De By. (mildew of the vine). He found it was very inferior to blue vitriol and incapable of replacing it.

CHAPTER XVIII.

DERIVATIVES OF CARBON (CARBON COMPOUNDS)—PRODUCTS DERIVED FROM THE FATTY SERIES—PETROLEUM (BURNING OIL)—PETROLEUM SPRAYS—PETROLEUM OIL EMULSIONS—PETROLEUM-SOAP EMULSIONS—PETROLEUM SPIRIT—VASELINE—ACETYLENE.

110. Petroleum.—Natural Occurrence.—Petroleum is a natural mixture of all the formenic hydrocarbides.[1] They are found together in these mineral oils from butane, even from ethane and propane to hexadecane. All these hydrocarbides are normal in structure without lateral chains, as C^nH^{2n+2}. But the composition of these petroleums is not everywhere the same. American petroleums contain, besides saturated hydrocarbides of the formulæ C^nH^{2n+2}, some non-saturated hydrocarbides of the series C^nH^{2n}, as well as a little cumene and mesitylene. Caucasian petroleum consists of polymethylenic hydrocarbides. Petroleum forms large subterranean sheets which constitute naphtha (crude oil) and which are wrought by means of wells. Petroleum is found in Alsace in the departments of Herault and Isere, at Saint Boes in the Lower Pyrenees, in Dauphine, etc. The origin of these sheets [of petroleum] is due to the subterranean decomposition of vegetable remains or to the action of water at high temperatures on metallic carbides, such as carbide of iron, which exists in subgranitic regions. At Smyrna petroleum issues, in fact, from granitic ground itself, below which there cannot be deposits of coal or organic matter.

$$Fe_2C + 2SiO_2 + 2H_2O = 2FeOSiO_2 + CH_4.$$

Commercial Products.—In the industry the petroleums are separated by [fractional] distillation and classed according to their volatility thus:—

1. *Petroleum Ethers.*—Hydrocarbides, B.P. 0°-70° C.; D. = 0·600-0·650. Consist especially of pentane and hexane.

2. Petroleum spirit (commercial ligroin), B.P. 70°-120° C.; D. = 0·650-0·720. Consist especially of heptane and octane.

3. Petroleum oil (burning oil, photogene), B.P. 120°-280° C.; D. = 0·750-0·820.

4. Heavy petroleum oils, B.P. 280°-380° C.; D. = 0·820-0·870.

5. Crude paraffin wax (paraffin scale), M.P. 30°-65° C.; B.P. 170°-254° C.; D. = 0·900-0·950 from $C_{17}H_{36}$ to $C_{25}H_{52}$.

6. Vaseline, unctuous, inodorous, unoxidizable grease, M.P. 30°-

[1] *Translator's Note.*—Known to us as the marsh gas or paraffin series, but to the disciples of Berthelot as the formenic hydrocarbides.

40° C.; obtained by distillation of petroleum so long as it yields volatile compounds, then by oxidizing the residue in the open, and filtering through animal charcoal.

Petroleum Oil or Burning Oil.—Petroleum oil or burning oil is that fraction from crude petroleum which is most used against insects which ravage plants. It is used as such, or in different emulsions.

Action of Petroleum on Plants.—Petroleum is very injurious to plants. Spraying with petroleum emulsions is almost always prejudicial to the leaves and tender branches. The poisonous capacity of petroleums of different compositions differ (Trott). The sensibility of different plants is different; whilst the cabbage stands a 5 per cent emulsion, the vine only bears 2·5 per cent, and even that injures the cucurbitaceæ. The action of emulsions depends greatly on their preparation; perfect emulsions diffused through much water do not separate drops of petroleum, that is to say, which do not split up have a comparatively harmless action on the leaves of plants, whilst badly prepared emulsions, allowing the petroleum to aggregate on the same point, are in equal doses very injurious. In using petroleum to destroy insects only perfect emulsions must be used. The prolonged contact of petroleum on the trunk of a tree may become deadly and must be avoided. The trunk and the branches coated, even in winter, absorb sufficient quantities of petroleum, which if they do not cause the death of the tree, at least so far disturb its economy as to retard the opening of the buds in the spring. Roots are likewise very sensitive, and the absorption of petroleum through them causes the death of the plant; 20 cubic centimetres of petroleum spread in 4 litres of soil kill the vine, haricots, and weeds, such as *Senecio* and *Sonchus*. A soil drenched with petroleum is no longer fertile, until the petroleum is evaporated, but then there is produced, as after treatment with carbon disulphide, a more intense vegetation resulting from the perfect disinfection of the soil by petroleum vapours. Withelm recommends steeping seed which it is desired to protect against insects sixteen to twenty-four hours in pure petroleum. This prolonged contact only slightly lowers the germinative capacity of the seed.

Action of Petroleum on Insects.—Petroleum acts on insects by contact, and by its asphyxiating vapours. Contact with pure petroleum causes the immediate death of all insects it is capable of penetrating, even those with the hardest shells, and protects them from the insecticides in aqueous solution. As an emulsion, petroleum is less energetic; eggs especially resist emulsions containing up to 30-35 per cent of petroleum (Smith, Lintner, Forbes), whilst 2·5-6 per cent emulsions kill all soft-skinned insects. The poisonous action of petroleum vapour never manifests itself in the open air, only in a closed vessel, or in the soil. In a closed vessel, Mouillefert destroyed the phylloxera by placing a contaminated root for two days in a 2-litre vessel containing at the bottom 5 cubic centimetres of petroleum. In the soil the injurious action does not occur, except at a short distance from the spot where the petroleum has been injected. From this point of view, petroleum is inferior to carbon disulphide and cannot replace it.

Use.—Burning oil has found the most varied applications in the

struggle against injurious insects, and its use is particularly general in America, where it is the best-known insecticide. It is used sometimes in the pure state, but generally in a state of emulsion with different substances capable of mechanically dividing it.

Use of Petroleum in the Pure State.—The action of petroleum on insects is radical and infallible; efforts have therefore been made to use it preferably in this form, so as to free it definitely from dangerous parasites, when there is no risk of destroying the plants treated at the same time. If it did not possess such a poisonous action on the plant it would be perfect. Unfortunately, the plant does not without special precaution stand contact with pure petroleum, and in spring or summer this method should only be used in exceptional circumstances. On the other hand, it is not dangerous to plants during the winter sleep, or as an injection in the soil some time before planting.

Marlatt recommends its use as a spray or sponge wash in winter on the aged part of trees for the total destruction of *Kermes* and *Scolytes*. But it was especially recommended by Webster for the destruction of *Aspidiotus* and *Lecanium* of fruit trees. Webster submitted his observations and his processes to the Congress of American Phytopathologists in 1896. Smith and Alvood write thus on the use of petroleum:—

"*Petroleum sprays* may be used with impunity on all fruit trees, even in full vegetation, by taking the following precautions. (If these precautions be neglected there will be a loss of 90 per cent of the trees treated):—

"1. Spraying should be done with an apparatus capable of reducing this liquid into a fine fog, capable of touching the whole surface of the plant without really moistening it. The formation of drops, which might flow along the trunk to the roots, must be avoided. Poisoning always occurs when the roots are drenched with petroleum.

"2. The operation must be conducted in warm, dry weather, for the petroleum should evaporate forthwith so as not to kill the plant.

"3. It is necessary to operate from March to September. In single treatments September is the month chosen.

"4. *Burning oil* (lamp oil) must be used and not crude petroleum, which contains insufficiently volatile ingredients.

"5. It is well to cover the fruit buds before spraying.

"In these conditions peach-trees and plum-trees are more sensitive than apple-trees and pear-trees. The trees treated have finer shoots, but the treatment appreciably diminishes the crop."

The report of the 10th Congress of the American Entomologists in 1898 is less enthusiastic on the use of pure petroleum. It concluded, after discussion, that pure petroleum is a highly dangerous insecticide for trees, but which may be unhesitatingly used when it is a case of the destruction of insects as formidable as the San José louse (*Aspidiotus perniciosus*) and certain kermes. In this case it must only be used on the old wood, and in dry, warm weather, in which it evaporates forthwith.

The Congress of 1900 was altogether unfavourable to the use of

pure petroleum, and declared against its use in arboriculture, remarking, however, that the 25 per cent emulsions if they have not on kermes such a radical action as pure petroleum, yet they completely destroy them if the treatment be repeated and used regularly.

Ocneria dispar, Sch. (gypsy moth).—Petroleum is more active than the tar generally used for the destruction of the eggs of this injurious butterfly. The destruction of the eggs is complete; a jet apparatus is used to localize the action of the pure petroleum on the aggregation of eggs alone.

Cossus ligniperda (*Cossus gâte-bois*) (goat moth). — Introduce petroleum into the tunnels dug in the trunk of trees and plug with mastic (Truelle).

Vespa (*Guepe*) (wasp) and *Formica* (*Fourmi*) (ants). — Pure petroleum is greatly recommended for the destruction of wasps' nests underground. Early in the morning, before the exit of the wasps, about a glass of petroleum spirit is run into the nest through the aperture, then the aperture is plugged, first with a pad drenched with petroleum, then with earth so as to prevent the vapours of petroleum from escaping. Carbon disulphide is, however, better than petroleum spirit.

Schizoneura lanigera, H. (woolly aphis).—Amongst the eighty-one methods recommended in 1903 to destroy this aphis, Thiele found that only pure petroleum, petroleum emulsion with soft soap, the alcoholic solution of corrosive sublimate, carbon disulphide, amylic alcohol, tar, and a mastic of lime and cow-dung, were capable of entirely destroying this aphis. All the other methods had only a temporary effect.

Phylloxera vastatrix (phylloxera of the vine).—Mouillefert found that petroleum had an immediate action on this aphis, but that its vapours alone acted slowly. Used to overcome the phylloxera on vines in pots the results were excellent, but there was complete loss on vines on the large scale. The aphis still lived on stocks which received up to 150 cubic centimetres of petroleum. Petroleum is thus much less energetic than carbon disulphide, for its diffusion through the soil is bad, so that it cannot act at a great distance from the spot where it was injected. The coating of the roots, proposed in 1872, was rejected as too dangerous to the health of the vine by the commission to investigate the different processes recommended to overcome the phylloxera. It would appear, however, that the disinfection of the vine by petroleum is possible by steeping the roots of uplifted stocks in a bucket filled with crude petroleum; the stocks replanted in a soil disinfected with petroleum yield vines the health of which is perfect and the roots of which show no more phylloxera.

Melolontha vulgaris (cockchafer).—The diffusion of petroleum through the soil is recognized as insufficient to destroy injurious insects or their larvæ beyond a very narrow zone round the hole into which petroleum was injected; it was, however, found that the vapours are disagreeable to the insects, and that these desert a field smelling of petroleum. Dorning and Decaux utilized this property to free fields, not only of white-worms, larvæ of the cockchafer, but also grey-worms,

caterpillars of the common dart moth, the larvæ of wire-worms, the nematodes, and the larvæ of the beet carrion beetle. It suffices at the time of tilling the ground to bury rags steeped in oil and petroleum from the factories rather deeply underground.

Gryllotalpa vulgaris (mole cricket).—Gemadius advises to destroy the grasshopper by running petroleum into the tunnels which it bores in the ground. A 25 per cent emulsion of petroleum is as effective as pure petroleum.

Culex pipiens (common gnat).—Two grammes of petroleum per acre suffice to form on the surface of stagnant water a pellicular layer which kills the gnats which live in the water. The larvæ of the common gnat, being amongst the number, it is easy to get rid of them.

Lepus europœus, L. (hare); *Lepus cuniculus* (rabbit).—Taschenberg points out the fact that trees treated by petroleum are respected by hares and rabbits, and Hofer advises simply to stretch a cord steeped in petroleum around the fields and gardens which it is desired to protect from these rodents.

Use of Petroleum as Emulsions.—Petroleum is divided mechanically into infinitely small particles by mixing it mechanically with finely divided solid substances, sand, earth, or with liquids, aqueous solutions, milk, or oil. The concentration and the composition of the emulsions vary greatly. Comparatively with pure petroleum a well-prepared petroleum emulsion, that is to say, homogeneous, behaves in its effects on plants and insects like a dilute solution. According to the concentration of the emulsion its capacity for injuring the plant as well as its insecticidal properties will be diminished or increased.

1. *Petroleum mixed with Sand.*—Perfect division of the petroleum is obtained by mixing it with sand or earth as follows: Petroleum 1 litre, sand 4 litres (Ritzema Bos); petroleum 1 litre, sand 40 litres (Husson). It is used especially when a small amount of petroleum is to be spread over a large surface. The amounts given above suffice for 25 square metres of soil, say 30 square yards. The action of the petroleum in these conditions lasts ten to fifteen days.

2. *Petroleum Emulsion and Water.*—Petroleum is insoluble in water but it is capable of forming with it milky mixtures termed "emulsions," which have the properties of a solution. It is, however, difficult to obtain a perfect emulsion with these two bodies so different in density; even the special apparatus like that of Goff accomplishes the end in view with difficulty. Aqueous petroleum emulsions are very unstable, and petroleum aggregates quickly to reform a layer on the surface of the liquid. Petroleum and water emulsion is not perfect enough to allow it to be used on the tender parts of plants, and it is now no longer used except to disinfect trees in winter, to spread petroleum uniformly over the fields, and to disinfect seed. Lossen designed a simultaneous double jet of water and petroleum meeting with force in a common space, and producing a perfect emulsion, but this emulsion likewise dissociated on the surfaces touched, forming big drops of petroleum, always injurious.

3. *Lime and Petroleum Emulsion.*—Galloway recommends an

emulsion made with 1 part of thick milk of lime from fat lime and 5-30 parts of petroleum. This emulsion is more stable than that made with water, but less so, however, than that made with soap solution. It was especially intended to be added to arsenical bouillies to increase their insecticidal value.

4. *Petroleum Emulsion with Salt Water.*—This emulsion is more difficult to make than that made with pure water, owing to the greater difference between the densities of the two products. It is frequently used in Switzerland, owing to its precious properties against the woolly aphis: 8 lb. of petroleum are emulsified with 2 lb. of a 25 per cent solution of common salt.

5. *Petroleum Emulsion and Soap Solution.*—Petroleum gives with soapy solutions very stable emulsions. All soaps do not lend themselves thereto equally well. *The soap which gives the most perfect emulsion is made in America from whale oil.* These emulsions keep a very long time whilst those made with other soaps become curdy in a few days. To increase the stability of emulsions made from ordinary soaps, alcohol or carbonate of soda is added. Concentrated stable emulsions are prepared with the appearance of a cream which are suitably diluted at the moment of use. A good preparation should be capable of being diluted to a certain extent without drops of petroleum forming on the surface of the liquid.

Example.—$2\frac{1}{2}$ lb. of soap are cut into thin slices and dissolved in 1 gallon of boiling water. After drawing the fire there is added slowly with constant stirring 10 gallons of petroleum at 18°-20° C.; petroleum only emulsifies with difficulty below this temperature. To obtain a perfect emulsion it is necessary on the large scale to stir with a mechanical agitator, on the small scale with an ordinary spraying machine drawing in the mixture and expelling it repeatedly. The emulsion is more perfect if another gallon of boiling water be added and the whole mixed once more. Rain water or distilled water should be used, or the hard water available corrected by carbonate of soda. Very different mixtures have been recommended; the following are the principal ones:—

TABLE LIX.—*Showing the Ingredients of Several Petroleum Emulsions.*

Water.	*Petroleum.*	*Soap.*
10 gallons	25 gallons	50 gallons soft soap (Cooke)
10 "	10 ,,	100 lb. soft soap (Kruger)
—	10 ,,	25 ,, ,, ,,
10 ,,	20 ,,	6 ,, ordinary soap (Hubbard Riley)
10 ,,	6·7 ,,	6·7 ,, ,, ,, (Ritzema Bos)
10 ,,	20 ,,	12 ,, ,, ,, (Alvood)

These emulsions are comparatively stable, less so, however, than those now *made with whale oil* and intended to be kept. They are thinned when about to be used in such a way that the emulsion only contains 2·5-6 per cent of petroleum, quantities which, according to Fleischer

and Kruger, should never be exceeded if the emulsions are to be used on the tender parts of plants. Schoyen asserts that they do not damage the leaves, especially when the composition is unimpeachable. Generally dilute and homogeneous emulsions are made when about to be used; the following are some proportions recommended:—

TABLE LX.—*Ingredients of Four Stable Petroleum Emulsions.*

Water.	*Alcohol.*	*Petroleum.*	*Soft Soap.*	*Carbonate of Soda.*	
100	—	1	1	—	Rathay
100	0·5	2	3	—	Caruso
100	—	1	2	1	Delacroix
96	—	1	2	2	Fleischer

These four emulsions are very stable and can be kept. They are the best. Petroleum and soap emulsions have entirely replaced those of milk and petroleum. They are in current use in America.

6. *Emulsion of Petroleum with Fish Oil.*—There are emulsified together at 60° C. petroleum 15 lb., fish oil $2\frac{1}{4}$ lb., water 15 gallons.

7. *Petroleum and Milk Emulsion.*—Curdled milk forms perfect emulsions with petroleum (Barnard, 1891): $2\frac{1}{2}$ gallons of turned milk are diluted with 10 gallons of hot water, then 20 gallons of petroleum are added with constant stirring. Ten gallons of petroleum and 5 gallons of curdled milk can also be emulsified together. If it be desired to use fresh milk a little vinegar must be added. Sorauer prepares the fresh milk emulsion although it is not made so easily. To obtain a perfect emulsion the liquid to emulsify must be drawn in and expelled for three-quarters of an hour, if the mixture be at 16° C., during fifteen minutes at 24° C. (Hubbard). This emulsion is diluted with twenty times its volume of water before use. The stability of this concentrated emulsion is less than that of a petroleum and soap emulsion. Unless it be kept in vessels absolutely closed it spoils in eight to fifteen days. According to Cooke, plants suffer more from this preparation than from petroleum soap emulsions.

8. *Petroleum Emulsion containing Insecticides and Metallic Salts.*—By adding to petrolo-saponaceous emulsions either extract of hellebore, arsenite of copper, or any other poisonous substance, the effect of the emulsion is strengthened and a more desirable action obtained. An emulsion, for example, is made with petroleum $\frac{1}{4}$ gallon, soft soap $7\frac{1}{2}$ lb., hellebore $2\frac{1}{2}$ lb., water 100 gallons. Smith advises the addition of $2\frac{1}{2}$ per cent of petroleum to a cupro-arsenical bouillie. The bouillie is stable, and the petroleum remains longer in fine division on the leaves than in pulverizing ordinary emulsions. According to the sensitiveness of the plant or the resistance of the insect submitted to the action of this bouillie, the dose of petroleum is increased or diminished. Kruger advises an emulsion made with equal parts of petroleum, soft soap, and water, to which quassia or tobacco juice is added. Diluted before use with ten to twenty times its volume of

water, this emulsion kills insects and prevents their return much longer than a simple emulsion. In South America flowers of sulphur are incorporated in the emulsions. They have been successfully used against *erinoses*. Galloway and Marlatt recommend adding a proper quantity, 2-6 per cent, of petroleum to bouillie bordelaise. These mixtures are more stable than simple emulsions, they keep for eight days. Of all the emulsions described, those made with soap and petroleum are to be preferred.

Use against Injurious Fungi.—*Potato Scab.*—This disease, characterized by an enormous development of the periderm, is caused by a special bacteria. It may be prevented if some hours before planting the soil be impregnated with an emulsion of soap 12½ lb., petroleum 4-5 gallons. This amount suffices for 24 square yards (Frank and Kruger).

Use against Coleoptera and their Larvæ.—It is impossible to enumerate all the insects overcome by petroleum. The following are some typical examples :—

Melolonthinæ (cockchafers).—The larvæ of the cockchafers—*Melolontha vulgaris*, the common cockchafer; *Melolontha Hippocastani*, the horse-chestnut cockchafer; *Melolontha Fullo*, teasel cockchafer; *Lachnosterna arcuata*, red cockchafer—are destroyed, or at least so inconvenienced, by the presence of petroleum in the soil that they soon desert it. This effect is best obtained by burying to a depth of 30 inches rags steeped in petroleum. Perkins, Alvood, Schoyen, and Marlatt obtained satisfactory results by the use of aqueous or soapy emulsions. They found that it was not enough to kill the larvæ of these insects to sprinkle the soil around the plants with 3·5 per cent emulsions, for the larvæ descend into the untouched deep layers, from which they ascend some time afterwards. The results are, on the contrary, appreciable when the moment is chosen when the larvæ have regained the surface layers of the soil to dig deep narrow holes between the rows of the young pine or spruce plantations or round the vine stocks in vineyards. A 20 per cent emulsion of petroleum is run into the holes, which are then filled up with earth, and an hour afterwards sprinkled with water. Used in this way, petroleum destroys a great portion of the larvæ of these lamellicorns, and protects the plant for a certain time against fresh attacks. In Norway, young plantations of conifers are successfully protected by pouring into the holes prepared before planting an emulsion of 1 part of petroleum with 13-15 parts of water. In America, Perkins advises spraying meadows with emulsions, harmless to grasses, to free them from the larvæ of the *Lachnosterna* and the *Allorhina nitida*.

Elateridecæ (wire-worms).—The larvæ resist the usual insecticides better than soft-skinned larvæ. Comstock and Slingerland found petroleum emulsions without action on these larvæ. Perkins regards them as inefficient and Tarzioni-Tozzetti was only partially successful with an emulsion of petroleum with fish oil.

Curculonidæ (weevils).—To get quit of the anthonomes of flowers, and prevent them laying their eggs, very dilute emulsions of petroleum may be used, sprayed on the flowers before flowering. Schilling ob-

served that this practice succeeded in freeing strawberries from the strawberry anthonome (*Anthonomus rubi*, Hbst.).

Scolytidæ (scolytides).—Winter treatment of trees by the petroleum emulsions destroys both *Xylophagus* insects which live in burrows dug in the bark of the trees, or immediately underneath it. F. H. Chittenden recommends this treatment especially against *Scolytus rugulosus*, Ratz. (scolytus of fruit-trees).

Chrysomelinæ (chrysomelines).—These may be destroyed by petroleum emulsions, especially if hellebore or quassia extracts be incorporated therewith. Comstock, Slingerland, Smith, and Von Schilling recommend the use of soapy emulsions as effective against *Criocerus Asparagi* and *Phædon armoraciæ*, L. (chrysomelide of the radish), (cochlearia). They destroy the larvæ.

Halticinæ (altises).—Petroleum is very useful in destroying them, and its good effects on a large number of species have been recorded, viz.: *Haltica oleracea*, L.; *Phyllotreta nigripes*, F.; *Phyllotreta sinuata*, Steph.; *Phyllotreta undulata*, Kutsch.; *Phyllotreta nemorium*, L., injurious to the cruciferæ; *Psylliodes affinis*, Payk., injurious to the potato; *Haltica vittula*, Redt., injurious to cereals; *Haltica rufipes* L., injurious to peas and haricots. In the same way as the individual altises whose sensitiveness to petroleum has been the object of the above special observations, all altises in general are killed by petroleum. Care must be taken not to use too concentrated emulsions so as to safeguard the plant invaded by the ravisher and only use perfectly homogeneous preparations. This point is much more important, as the organs sought after by the altises are the most tender part of the plant, and, consequently, the most sensitive to the action of petroleum. Ritzema Bos advises to get rid of altises the use of an intimate mixture of 4 litres of petroleum and 16 litres of sand for 100 square metres of soil. Used on the spot invaded by the earth-lice, it is found that they immediately quit the plots treated and do not return until ten to fifteen days later. This method gets quit of altises when the plant is small and much exposed to complete destruction by the altise. Comstock, Slingerland, and Lampa advise the use of emulsions with quassia extract for the same purpose. Petroleum and soap emulsions are perfectly capable of being of service to agriculturists as destructors of Coleoptera, especially when it is a question of their larvæ. In any case, the smell of petroleum is so objectionable that those not touched by it desert the plant treated. Smith, Lintner, and Forbes have shown that the eggs of the insects have such a resistance that a 30 per cent emulsion of petroleum does not kill them.

Use against Hymenoptera.—*Lophyrus Pini*, *Lophyrus rufus* (the pine saw-fly).—Ritzema Bos advises petroleum emulsions to destroy the larvæ of these lophyres. Their larvæ are very sensitive, especially when young. The treatment does not injure the pines.

Nematus Ribesii (nematode of the gooseberry), (gooseberry saw-fly).—According to Johnson the young larvæ are killed by a 12 per cent emulsion, the adults by the same emulsion containing 0·6 per cent of hellebore decoction.

Use against Lepidoptera.—Lepidopterous caterpillars are gener-

ally very sensitive to petroleum, and easily destroyed. According to Bretscher the caterpillars do not resist a 3-6 per cent petroleum emulsion. According to Schoyen a cupro-arsenical bouillie of 0·05 per cent of emerald green is superior in its action to milk of lime emulsions. According to Moor the grubs touched appear for some time to be dead, but recover after a while.

Pierides.—White cabbage butterfly grubs are not killed except by a 6 per cent emulsion of petroleum. At that concentration 75 per cent of the caterpillars are killed. More concentrated emulsions are injurious to the leaves (Alvood). It is preferable to preserve cabbages by keeping off the butterflies. For that purpose it suffices, according to Prins's experiments, to sprinkle cabbages with a weak emulsion.

Ocneria dispar, Sch. (gipsy moth).—Petroleum emulsion is of great service. Berlese found that a 5 per cent emulsion kills them outright. To destroy the eggs, pure petroleum must be used.

Noctuidæ (*Noctua*).—Petroleum emulsions kill the numerous caterpillars of Noctuæ.

Agrotis Segetum, W. V. (the common dart-moth grey-worm).—Not only are the caterpillars of the common dart-moth called grey-worms but also those of many other species of noctua, because they all have the same nocturnal habits and much resemble each other. These caterpillars often hibernate, and make considerable ravages in the spring by nibbling the young shoots of cultivated plants. The ravages are often so great that their destruction by petroleum is always necessary unless there be many toads on the spot, which are always great destroyers of these caterpillars. According to Decaux' experiments made in 1892, three toads suffice per acre to defend a crop. Riley advises to kill grey-worms on the large scale by an emulsion containing 0·5 per cent of soap and 1 per cent of petroleum, which is sprayed on the fields at the rate of about 1000 litres per hectare (88 gallons per acre). Degrully advises a mixture of sulphur 6 lb., lime 4 lb., petroleum 10 gallons. Burning rags steeped in petroleum drives them away without destroying them.

Charaeas graminis.—The caterpillar of this butterfly devastates meadows when it appears in great numbers (Bremen, 1816 and 1817). Reuter found that they resist a 6·6 per cent emulsion.

Mamestris Brassicæ, L. (the cabbage moth).—The invaded cabbages must be sprinkled with a 6 per cent petroleum emulsion. A weaker emulsion may be used as a preventive before the butterflies lay their eggs on the young cabbage. Petroleum emulsions have likewise been tried to combat Tortricides.

Conchylis ambignella, Hubn. (cochylis of the vine).—Zecchini and Silva found that its caterpillar, the worm of the vintage, is destroyed by an emulsion of 2·5 per cent of petroleum and 1 per cent of soap. The vine leaves are sensitive to greater strengths; this dose should not be exceeded.

Amongst the Tineides or Tinea :—

Plutella cruciferarum, Zell. (diamond-back moth).—Petroleum is used in the same way as to combat the cabbage noctua. They are easier killed if the emulsion contains quassia extract (Fleischer).

Hyponomeuta malinella, Zell. (small ermine apple moth).—Schoyen advises a 10 per cent emulsion against the caterpillars of this tinea. The results are grand. At that strength the emulsion even kills the chyrsalides. The action of petroleum can be localized on the nests by applying with a brush a 12 per cent emulsion in the evening when all the caterpillars have re-entered the nest.

Use against Hemiptera.—The phytophagus bugs are destroyed by petroleum emulsions.

Eurydema ornatum (*Pentatoma ornata*), *Eurydema oleraceum* (*Pentatoma oleracea*).—To kill this bug it takes strong (6-10 per cent) emulsions of petroleum; generally they injure the plants as much as the bugs. To obtain a perfect result Wood advises to operate thus: Intercalate in the crops affected by these insects the plants preferred by them, on which they are not long in installing themselves in mass. On these they are destroyed with strong emulsions, which kills them at the same time as the bait plants. In this way, between the rows of potatoes, mustard radishes or other crucifers are planted.

Lygus pratensis (meadow bug).—May be destroyed by a 15 per cent petroleum emulsion.

Halticus Uheleri (Giard).—Petroleum emulsions destroy it (Chittenden).

Oxycarenus hyalinipennis, Costa (cotton bug).—Marshal destroys it with petroleum emulsions.

Tingis Piri (tiger beetle of the pear).—These are killed by spraying under the leaves principally an emulsion containing 1 per cent of soft soap, 1 per cent of petroleum, and 1 per cent of carbonate of soda. According to Debray, the winter treatment of fruit trees with 12-25 per cent emulsions destroys these injurious insects in their winter refuges.

Use against Homoptera.—The *Cicadellides*, small grasshoppers, a few millimetres in length, are often injurious to crops. Petroleum emulsion kills them effectually.

Jassus sexnotatus, Fall. (grain grasshopper).—Sorauer has used with success a milk emulsion of petroleum consisting of 2 parts of petroleum and 1 part of milk, diluted with twenty times its weight of water. Used against the grain grasshopper it is more active than lysol and Nessler's liquor.

Typhocyba Solani, Kll. (potato grasshopper).—Von Schilling recommends the use of soapy emulsions of petroleum to destroy this grasshopper. It is, however, well to use a strong emulsion, and wash the plant afterwards by spraying with water, as soon as the petroleum has acted on the grasshoppers.

Penthima atra (grasshopper of the vine).—Marlatt found that a 6 per cent emulsion kills this grasshopper. The vine only supporting a 2·5 per cent emulsion, the treatment should be followed immediately by washing the stocks treated with a spray of pure water. The psyllas or leaf lice are closely related to the aphis; they also are injurious to trees. They are killed by petroleum emulsions.

Psylla Pyri, L. (the pear chermes).—The larvæ are very sensitive to petroleum emulsions and may be destroyed, whilst the adults are

more resistant. According to Marlatt and Slingerland, 33 per cent emulsions do not act on the eggs, besides they resist pure petroleum, benzene, spirits of turpentine, carbolic acid, and liquid soda. Winter treatment with 25 per cent emulsions destroys the hibernating adults. Spring treatment with 2 per cent emulsion, at the time of the hatching of the larvæ, destroys 90 per cent (Slingerland). Fischer recommends the extract of quassia emulsion.

Psylla mali, Först (the apple chermes).—Winter treatment is without effect, for it is not the adults that hibernate but the eggs. It is better, therefore, to treat the larvæ in the springtime, some days after hatching, to obtain appreciable success. The more frequent victims of petroleum are the *Aphides* (lice), for the insects of that family are the most delicate. They are easily destroyed by emulsions when they are not sheltered in a fold of the leaf in galls (Tetraneura) or in cankers (Schizoneura) inaccessible to sprays. It is well, therefore, to proceed with the treatment before the louse has assumed a great extension, at the moment when it is discovered. In these conditions the destruction succeeds, and even the Delacroix 1 per cent emulsion. Nevertheless, Muhlberg Barnard, Fleischer, Koebele, and Alvood recommend a 3-4 per cent emulsion against the living lice in the open, as those of the rose. When the lice are protected under a curled leaf, as in the case of the apple, peach, and gooseberry, the treatment does not succeed; 6·6 per cent emulsion only killed 25 per cent of the gooseberry aphis. Kruger's emulsion, consisting of equal parts of soft soap, petroleum, and water, is most used in Germany and diluted so as to make a 1-6 per cent emulsion; in France it is Delacroix's containing 2 per cent of soft soap, 1 per cent of petroleum, and 1 per cent of carbonate of soda. The winter treatment of trees with concentrated emulsions, containing 25-30 per cent of petroleum, cannot act except on species which hibernate in the state of apterous females, for these emulsions are, according to Goff, incapable of killing the winter eggs.

Schizoneura lanigera, H. (woolly aphis).—The woolly aphis forms big cankers on the branches on which the colonies vegetate indefinitely. These lice form hiding-places there, where it is almost impossible to reach them, and as they are, moreover, covered with a sort of down, aqueous insecticides have no action on them, for they neither reach nor penetrate them. The moment must be chosen when the winter egg is hatched, for at birth the insects have no down, are delicate and frail. Concentrated emulsions containing as much as 66 per cent petroleum can then be used on the cankers, preferably after excising the ligneous portion. Success is absolute, yet Delacroix and Fischer remark that an ordinary 3·5 per cent emulsion, and even with 1 per cent of petroleum and 1 per cent of carbonate of soda, acts on all the lice it touches. Failures only occur with too thick colonies that cannot be penetrated by the insecticide. In Switzerland, petroleum and salt water emulsions are used with success. According to Stedman (Missouri Experimental Station), the ravages of the woolly aphis also affect the underground portion of the apple-tree. He succeeded in disinfecting the young trees without injuring their health, by uplifting

them, cleaning their roots, cutting out any nodosities if need be, and immersing the roots in a petroleum (kerosene) bath consisting of 2½ lb. of soft soap, 9 gallons of petroleum, and 90 gallons of rain water.

Coccides.—In spite of the thick shell which protects the coccides, they may be overcome by petroleum and its emulsions when they live in the open. Petroleum is one of the rare substances which really act on coccides. In the pure state its action is radical. It is recommended in that state when it is a case of a dangerous invasion which must be stopped by the complete destruction of the parasite. When cochineals such as *Aspidiotus perniciosus*, Comst. (San José louse), *Aspidiotus ostreaformis*, Curtis (pear-tree oyster scale), an American coccide the appearance of which was first reported in France in 1892, *Mytilaspis pomorum*, Hook (apple-tree mussel scale), *Diaspis piricola* (pear cochineal), and others—when these make their first appearance in an orchard, pure petroleum must be used, taking the precautions previously described—precautions which are indispensable to preserve the tree in good health and circumscribe the plague. In most cases emulsions may suffice, and where the dangerous coccides are in the endemic condition, as in America, regular annual treatment with dilute emulsions prevents their too great multiplication in orchards without completely destroying them. It is the same with the coccides as with the phylloxera. There is an extinction treatment when this insect makes its first appearance, and a cultural treatment where it lives in the endemic state and where it suffices to create a *modus vivendi* between the tree and its parasite. Cultural treatment is effected with dilute solutions, especially if the moment chosen for treatment be that when the young delicate larvæ emerge from the protective carapace of their mother, where they have been sheltered during the first days of their larval evolution. At that time they are as sensitive as the aphides and succumb to 2·5 per cent emulsions (Fleischer) or 6·6 per cent (Kruger), which no longer injure the tree. The adult females covered by their carapace are more resistant. In winter, 25-30 per cent emulsions must be used against *Aspidiotus*, 12-15 per cent against *Lecanium nigrofasciatum* (kermes of the peach, Johnson), 5-10 per cent against kermes of the lemon-tree. It is well to give several treatments, at eight or fifteen days' interval, as advised by Belle, and to follow this winter treatment by a spring treatment with a weak emulsion intended to destroy the active larvæ. In this way the treatment is complete and without injury to the fruit tree. Belle advises this treatment to destroy *Chrysomphalus minor* (orange cochineal), Targioni-Tozzetti to destroy *Pulvinaria vitis*, L. (vine cochineal), and Marchal to overcome *Guerinia serratulæ*, Fab. (kermes of the pine, cypress, and acacia). Petroleum and its emulsions applied judiciously are capable of easily destroying the coccides.

Use against Diptera.—*Psila Rosæ*, Fabr. (carrot fly); *Anthomyia Brassicæ*, Bouché (turnip fly).—Schoyen recommends 12 per cent emulsions to overcome these flies which do great damage.

Use against Acari.—*Tetranychus telarius* (red spider).—Kolbe advises the use of an emulsion of 1 per cent of petroleum and 1 per

cent of soap, Fernald that of an emulsion containing quassia. Emulsions of 3-4 per cent containing a little suspended sulphur are also recommended.

Phytoptides.—To destroy them action must be taken the moment they invade the buds, that is to say, at the moment the acari are grouped around these. This treatment is especially used in South America where acari cause frequent ravages.

III. **Petroleum Spirit.** — **Preparation.**—Petroleum spirit is rectified petroleum, collecting by distilling the hydrocarbides boiling between 100° and 150° C. (212-302° F.).

Action on Plants.—Petroleum spirit is regarded as less injurious to the tender parts of plants than petroleum oil; applied by spraying on the plant it evaporates more rapidly and the plant does not remain so long in contact with it.

Action on Insects.—Petroleum spirit appears less active on insects than petroleum oil, and it must be used in larger doses than the latter. Used in the soil, its radius of action is more extended, which renders it more apt to overcome underground insects.

Use.—Alvood and Slingerland tried to replace petroleum oil emulsions by petroleum spirit, but they found the latter inferior. Mohr, on the other hand, reports the good services rendered against underground parasites by the following emulsion:—

Mix together 2½ lb. of oleic acid and 2½ lb. of ammonia, then add 1 gallon of petroleum and 1 gallon of petroleum spirit. By an intimate mixture made by a spraying machine a stable emulsion of syrupy consistence is obtained. For the destruction of underground parasites, such as nematodes, larvæ of melolonthides, noctua wire-worms, mole crickets, etc., 1 gallon of this emulsion is mixed with 20 gallons of water. The dilute emulsion contains about 4 per cent of petroleum, and behaves in the same way as the ordinary emulsions of soap and petroleum. To obtain complete destruction Mohr says it is not enough to spread the preparation in the soil; holes must be pierced every 20 centimetres (8 inches), 30 centimetres (12 inches) in depth, and into which 20-30 cubic centimetres of emulsion, say up to a fluid ounce, are poured; then the holes are plugged.

Ceuthorhynchus sulcicollis, Gyl. (cabbage weevil).—Underground injections of diluted Mohr's emulsion kill it, also the following: *Otiorhynchus sulcatus* (vine weevil); *Molytes coronatus*, L., weevil injurious to beets, because it perforates their leaves.

Conchylis ambignella (cochylis of the vine).—Del Quercio advises an emulsion of 1 per cent petroleum and 1 per cent of soft soap. Caruso got excellent results by a bouillie of 2 per cent petroleum spirit, 3 per cent soft soap, and 0·5 per cent alcohol. As for petroleum emulsions, this emulsion must be made ten times more concentrated, and diluted at the time of use by hot water. By applying this emulsion on the caterpillars, Martini destroyed 94 per cent, whilst Dufour's pyrethrum bouillie only destroyed 79 per cent, and rubinia (wood tar) of 5 per cent strength only 73 per cent.

Tingis Piri.—Del Quercio describes the good effects of an emulsion of petroleum 1 per cent and soft soap 1 per cent.

Lopus sulcatus (*grisette de la vigne*).—Pratigeon destroys the adult larvæ by emulsions of petroleum spirit, or of carbon disulphide. So as not to hurt the vine, he begins the treatment at the time when this insect has already invaded the young grapes; but it must be attacked before hatching on the plants on which it feeds most willingly. A slight shake is given to the stock; the larvæ, which are already clinging to the vine, fall to the ground forthwith and the emulsion is then projected on to the soil. To kill the perfect insect, an emulsion diluted to at least 2 per cent is projected on the fruit.

112. Vaseline.—Action on Plants.—Vaseline is not harmless to plants as might be imagined. It acts injuriously like petroleum hydrocarbides. Shearer found that plants do not support with impunity larger doses than 10 per cent. Goethe and Marchal found that vaseline used as an asphyxiating ointment on the cankers produced by the woolly aphis is injurious to the plant.

Action on Insects.—Like oils and fats in general, vaseline acts on insects as an asphyxiant; it would appear at the same time to exercise a toxic action analogous to that of petroleum on insects and their larvæ; contact with it or its emulsions diluted even to 10 per cent is deadly.

Use.—Vaseline has been used to prepare the sulphuretted vaseline invented by Meunier in 1887, to overcome the phylloxera. Vaseline rapidly diminishes the evaporation of carbon disulphide in the soil, and prolongs its action. Vaseline forms emulsions with soapy water of the same strength as petroleum, and such emulsions are used in the same condition; they are especially used in England. Ward advises an emulsion of vaseline 0·5 per cent, soap 1·25 per cent, against all garden insects.

Anthomyia Betæ (beet fly); *Anthomyia antiqua*, Meig. (onion fly); *Anthomyia furcata*, Bché. (onion fly); *Anthomyia ceparum* (onion fly); *Psila Rosæ*, Fabre (carrot fly).—Whitehead destroys these flies by an emulsion of vaseline 10 per cent, soft soap 0·25 per cent. It is used as a spray round the plant before the appearance of the fly.

Thrips cerealium (thrips of cereals).—Shearer destroys these insects by spraying with emulsions of vaseline 7 per cent, soft soap 8 per cent.

Aphides.—Plant lice are killed by an emulsion of vaseline 0·75-1·0 per cent and soft soap 0·5-0·75 per cent (Whitehead); vaseline 3·5 per cent and soft soap 7 per cent (Shearer).

Coccides.—To kill cochineals and kermes emulsions of vaseline 10-12 per cent, soft soap 8-10 per cent, must be used.

113. Acetylene,[1] C_2H_2.—**Preparation.**—Coal gas destroyed by sparking or incompletely burnt yields this unsaturated hydrocarbide. It is obtained commercially by decomposing with water acetylenic carbides, such as calcium carbide.

$$CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2.$$

As the commercial carbide is always impure, there is formed in ad-

[1] Acetylene is like coal-gas explosive when mixed with a certain amount of air. Anyone storing calcium carbide must comply with the Home Office regulations thereanent.—Tr.

dition ammonia 0·24-0·4 per cent, sulphuretted hydrogen 0·7-0·9 per cent, phosphuretted hydrogen 0·018-0·032 per cent (Chuard).[1]

Properties.—Acetylene is a colourless gas with a slight alliaceous odour; it burns with a bright flame. One kilogram of calcium carbide disengages 300 litres of acetylene.

Action on Plants.—Acetylene has no injurious action on plants. Leoni found that the germinative capacity of peas and grain did not suffer from its contact. At a certain strength it must, however, act like coal gas, which is known to be injurious to plants.

Action on Fungi.—Calcium carbide applied with the bellows, like sulphur, and projected on to the fungi moistened with water, appears to be injurious to them, but it only kills the fungi touched. Moreover, the action of acetylene on fungi is still badly understood.

Action on Insects.—Placed in an atmosphere containing 10 per cent of acetylene insects die in twenty-four hours. Perfect insects and larvæ of the pea weevil. *Bruchus* (*Bruchus pisi*, L.), hidden in the peas die by the acetylene disengaged when they are enclosed with a small piece of calcium carbide in a closed space.

Use.—*Oidium Tuckeri*, Berk. (oidium of the vine).—Huchet was the first to try calcium carbide on the vine to kill oidium. After moistening the diseased grapes with the spraying machine, finely pulverized calcium carbide was applied by a sulphur bellows. The effect produced was decisive, and in spite of the great heat, neither the grapes nor the leaves suffered. Since then calcium carbide was tried, comparatively, against sulphur in Champagne in the vineyards of Chandon de Briailles, with the result that sulphur and calcium carbide cannot be used indifferently in the different phases of the disease. When a stock attacked by oidium has been treated with sulphur, it may be taken for granted, if rain does not intervene and if the weather is warm, that the vine has been protected against the disease for a month at least. But the very great efficiency of sulphur when the disease is recent is less when the attack is an old one. Calcium carbide does not kill the oidium except when it is in contact with the fungus, and, moreover, so that it can act the attacked grapes are moistened when the carbide dust is projected on to them. Under such conditions, the action of the product is somewhat energetic on strongly attacked grapes. In similar circumstances the action of sulphur would be less pronounced. The use of calcium carbide would not appear to be indicated except on grapes to overcome an old and intense attack of oidium, when the sulphurings have not been numerous enough or when weather conditions have diminished the destructive capacity of sulphur.

Guignardia Bidwelli, V. and R. (black rot of grapes).—In the beginning of September, G. Rodies dusted with calcium carbide the tendrils of the still green grapes attacked with black rot. Some days after this treatment the fungus had disappeared. Held describes the

[1] Chuard and Ettli believing that phosphuretted hydrogen may aid to a great extent the insecticide action of calcium carbide, prepared calcium phosphide, Ca_3P_2, which is decomposed by water into lime and phosphuretted hydrogen, so as to test it comparatively against calcium carbide.

injurious action of the lime from acetylene factories used in place of ordinary lime to coat trunks of fruit trees.

Destruction of Insects. — *Melolonthides* (cockchafers). — Scribaux and Chuard recommend acetylene against the enemies of crops. They propose to incorporate in the soil, preferably deep down, a sufficient quantity of calcium carbide in small pieces, which by the moisture of the soil would be decomposed into acetylene. This decomposition occurs slowly and gradually. An insecticide gas is formed capable of occupying a considerable volume of the soil treated. Weak doses in Germany had no effect. Pieces of carbide of about 50 grammes, say $1\frac{3}{4}$ oz., buried 8 inches down every metre is not enough, as 1 kilogram only yields 300 litres of gas (1 lb. yields 30 gallons).

Phylloxera vastatrix (phylloxera of the vine).—Chuard tried the cultural treatment of the vine against phylloxera by means of calcium carbide. His trials in the neighbourhood of Annecy show that vines treated with carbide exhibit a greater vitality and vigour than the neighbouring untreated stocks, and on examining several stripped stocks the phylloxera was absent. The process consisted in stripping the roots and adding 100 grammes, say $3\frac{1}{2}$ oz., of coarsely crushed carbide. Trials in Germany on the contrary proved that carbide is unable to overcome the phylloxera. The question is far from decided, and it is very possible that in carbide we possess an excellent insecticide capable of freeing crops from underground parasites.

CHAPTER XIX.

CARBON COMPOUNDS (*continued*)—CHLOROFORM—CARBONIC OXIDE—METHYL ALCOHOL—ETHYL ALCOHOL—AMYLIC ALCOHOL—GLYCERINE (TRI-HYDRIC ALCOHOL)—ETHER—MERCAPTAN—FORMIC ALDEHYDE—ACETIC ACID—OXALIC ACID.

114. **Chloroform,** $CHCl_3$.—**Preparation.**—Heat in a retort bleaching powder 10 lb., slaked lime 3 lb., ordinary alcohol 2 lb., water 6 gallons. The reaction commences at 80° C., and when the heat is lowered continues. Chloroform distils. The operation is stopped when 0·3 gallons of liquid has been collected. The liquid separates into two layers, the heaviest of which is chloroform.

Properties.—Chloroform is a colourless, very fluid liquid, with a sweet, pleasant odour, and a sharp, saccharine taste. It is only slightly soluble in water, but very soluble in alcohols. Chloroform is a powerful caustic; applied on the skin it irritates it to vesication and produces local anæsthesia; its anæsthetic action is due to a muscular paralysis of the heart. An atmosphere containing 4 per cent of chloroform is irrespirable. It is deadly at 8 per cent.

Action on Plants.—Its action resembles that of ether. Coupin submitted seeds to the action of chloroform vapours, and found that the dry seeds did not suffer in an atmosphere saturated with chloroform. It is quite otherwise with moist seeds, the protoplasm of which already shows some action. They are very sensitive to chloroform, and an atmosphere containing 0·037 per cent (3·7 grammes) in 10 litres of air is deadly. Wheeler made different trials to disinfect seed-corn by the vapours of ammonia, formol, and chloroform. He found grain stood the action of ammonia for twenty minutes, formol sixty minutes, and chloroform ten minutes, without losing their germinative capacity. Chloroform has a very peculiar action on the growth of plants. Mrs. Latham found that chloroform stimulated the growth up to a certain concentration and then slackened it. Kegel found on *Elodea* that the stimulating action of chloroform is only shown between 0·4 and 0·7 per cent, but that above or below these strengths growth is retarded.

[**Blooming by Chloroform.**—Professor Johannsen, of Copenhagen, has been chloroforming plants, and with marvellous results. He discovered that plants treated with anæsthetics were stimulated into extraordinary growth. His method is this :—

Lilies of the valley, azaleas, lilacs, and other dormant plants are placed in an air-tight box, to the lid of which is affixed a small vessel filled with chloroform. This, being heavier than air, settles down and mingles with the plants. At the end of forty-eight hours the specimens are taken out and grown in the ordinary manner.

Nothing in the way of forcing or artificial heat is required. Lilacs bloom within two weeks of being chloroformed, and lilies of the valley are hardly so long in coming to maturity.—Added by TRANSLATOR.]

Action of Chloroform Vapour on Spores.—Wheeler compared the action of formol, chloroform, ammonia, and carbon disulphide on the spores of *Tilletia* with the view of discovering a practical process for the disinfection of seed-corn by anticryptogamic vapours. He found that only the vapours of formol entirely, accomplished the end in view. Seed-corn is placed in a tube and the vapours of anticryptogamic substances are passed through it by aid of an air current. Wheeler in that way obtained the following results :—

TABLE LXI.—*Showing the Disinfectant Capacity of Anticryptogamic Vapours on Seed-Corn.*

Kind of Vapour.	*Action.*	*Diseased Ears, Per Cent.*
Formol vapour	15 minutes	0·00
Untreated	—	1·35
Ammonia vapour . . .	60 minutes	0·19
Untreated	—	0·48
Carbon disulphide vapour . .	21 minutes	0·15
Untreated	—	0·35
Chloroform vapour . . .	10 minutes	0·25
Untreated	—	0·35

Action on Insects.—Chloroform is poisonous to insects, its vapour kills them.

Use.—Coupin advises that in the struggle against the insects infesting granaries, carbon disulphide be replaced by chloroform which has the advantage when used on dry grain of not damaging it like carbon disulphide.

Coccides.—Reh found chloroform vapour acts very energetically against coccides. Coquillet who tried it against cochineal of the orange-tree and lemon-tree did not record perfect results.

114a. Carbonic Oxide, CO.—**Preparation.**—This gas is formed on every occasion that there is incomplete combustion of carbon owing to an insufficiency of air to form carbonic acid [to which it burns in air].

Properties.—Carbonic oxide is a poisonous gas. In doses of 4-5 per cent in the air it causes the immediate death of animals. This action is explained by the way it behaves to the hæmoglobin of the blood. By the combination which it forms with the latter it annuls more or less completely the property of the globules to fix oxygen.

Use.—Carbonic oxide is used to kill the chrysalis of the silk-worm by submitting the cocoons for eight hours to the action of this gas. Coquillet also tried unsuccessfully to destroy cochineals by the use of this gas.

Alcohols.—The alcohols enter into the composition of many insecticides because they are capable of mixing in all proportions with

water, and maintain in solution therein the insecticides insoluble in water.

115. Methyl Alcohol, CH_3OH.—Preparation.—Methyl alcohol or wood spirit is a product of the dry distillation of wood.

Properties.—Methyl alcohol is a colourless mobile liquid which boils at 66·5° C. It dissolves most substances soluble in ordinary alcohol, such as essential oils and resins. Oxidizing agents convert it first into formol and then into formic acid. [Highly inflammable.]

Use.—As a solvent in place of ordinary alcohol which it can replace in all insecticides with an ethylic alcohol basis.

Phylloxera.—Two mixtures have been patented in Germany for the destruction of this louse. The D.R.P. 50772 claims a solution of turps and quassia in methyl alcohol. and D.R.P. 47775 claims a solution of animal oil, colocynth, etc., in methyl alcohol.

Galeruca luteola (galeruca of the elm); *Erymia nitida* (diptera living on the elm).—It is recommended to destroy these by a mixture of water 100 gallons, tobacco juice 1 gallon, soft soap 10 lb., methyl alcohol 1 gallon, carbonate of soda 2 lb.

116. Ethyl Alcohol, C_2H_5OH.—Preparation.—By the action of yeast on saccharine solutions certain sugars are under such conditions converted into alcohol and carbonic acid. All that has to be done is to distil these liquids to obtain alcohol. Purification is effected by redistillation of the first distillate over lime.

Properties.—Alcohol is a colourless limpid liquid with an intoxicating odour; it dissolves in water in all proportions. Alcohol is a precious solvent not only of inorganic compounds like caustic alkalies, mineral acids, chlorides, and nitrates, but also of numerous organic compounds, such as essential oils, resins, camphors; it also dissolves fatty bodies, but with greater difficulty. Alcohol boils at 78·4° C.

Action of Alcohol on Plants.—Sandsten examined the action of alcohol on the growth of plants in a nutritive fluid. Alcohol in solution of 1 in 10,000 to 1 in 20,000 does not affect the growth of young plants of phaseolus, vicia, and maize. A 2 per cent solution is injurious, it excites the movements of the protoplasm and causes death. The vapours of alcohol may become prejudicial to the health of the plants if the atmosphere contains more than 1 in 10,000; greater amounts stop growth and cause death. Hiltner found that whilst ordinary alcohol of 95 per cent strength injures seed, absolute alcohol on dry seeds has no injurious effect. Alcohol would appear, therefore, to act on seeds like ether and chloroform.

Use against Insects.—Disinfection of Flower Seed.—Hiltner recommends to wash with absolute alcohol. The seeds should be dry and thus without protoplasmic activity.

Plant Lice.—Alcohol enters into the composition of many insecticides recommended against plant lice, but it is not so active as amylic alcohol which replaces it with advantage in all these mixtures.

Schizoneura Lanigera, Hausm. (woolly aphis).—Linière recommends a mixture of alcohol 30 oz., water 20 oz., potash 1 oz., applied by the brush on the colonies. In Germany this aphis is easily got rid of by drenching the colonies and the cankers which they produce, and

which protect them, with methylated spirit, which is then lighted. Reh found that alcohol does not kill coccides after two hours' action.

117. Amylic Alcohol, $C_5H_{11}OH$.—Preparation.—Crude ordinary alcohol always contains a certain proportion of amylic alcohol, especially if from the fermentation of potatoes. Amylic alcohol results from the secondary fermentation due to special ferments.

Properties.—Crude amylic alcohol used in agriculture is a colourless fluid with a sweetish smell which boils between 129° C. and 132° C. It is not perceptibly soluble in water, but it dissolves in ordinary alcohol.[1]

Action on Plants.—It is more poisonous to plants than ordinary alcohol. Mixtures of soft soap and amylic alcohol cannot always be used with impunity on plants without killing them (Fleischer). But this is greatly due to the action of the soft soap on the leaves and the young shoots of which a solution of 1·32 per cent strength produces effects followed by death, and of which a solution of 0·66 per cent injures plant growth considerably.

Action on Insects.—Amylic alcohol alone is less poisonous than its mixtures with soft soap. It does not kill the caterpillar of the cochylis. These mixtures have, however, a very categoric action on soft-skinned insects, such as plant lice and caterpillars, and are of universal use; they have a better action than aqueous insecticides, because they soften the insects touched. Used alone on the cankers of apple-trees produced by the woolly aphis they destroy it. Spraying with a mixture of water and 15 per cent amyl alcohol has been used to remove from meadows the laying females of the cockchafer.

Use.—The greater part of the insecticides of commerce are mixtures of amylic alcohol, soft soap, and an insecticide substance such as pyrethra powder, tobacco, etc. Only known insecticides need be quoted: "Nessler's," "Aphidin," "Antivermin," "Amylocarbol" in Germany; "Knadolin" in Switzerland; Fichet's insecticide in France recommended and recommendable for the destruction of plant lice and caterpillars. Their effects on these insects are indisputable. The following are the compositions of some of these insecticides:—

TABLE LXII.—*Showing the Composition of Nessler's Insecticides.*

	Lb.	*Lb.*	*Lb.*
Soft soap	4	30	5
Amyl alcohol	5	32	10
Ordinary alcohol	20	—	20
Tobacco extract	6	—	—
Potassium sulphide	—	2	—
Water (in gallons)	10	10	—

Knadolin.—Soft soap 40 lb., amyl alcohol 60 lb., nitrobenzene

[1] *Translator's Note.*—Amylic alcohol is a most unpleasant substance to handle. A piece of canvas or an old straw hat coated with a varnish in which amyl alcohol has been used to dissolve the resin used in the manufacture of the varnish should drive off all insects from the neighbourhood. The least trace of amyl alcohol in the air causes coughing of a most irritating nature, and an insecticide in which amyl alcohol has been used can readily be detected by this means. As the boiling-point of amyl alcohol is some 32° C. higher than that of water, it will readily be seen that its irritating vapour is persistent if not permanent.

2 lb., xanthogenate of soda 1 lb. The following mixtures are also used as insecticides:—

TABLE LXIII.—*Showing Composition of Mixed Amyl Alcohol Insecticides.*

	Lb.	*Lb.*
Green vitriol	1	—
Sulphate of alumina	—	4
Amyl alcohol	5	5
Water (in gallons)	10	10

An analogous insecticide is obtained thus: Dissolve 3 lb. of soft soap in 10 gallons of hot water, and add after cooling with constant stirring 6 lb. of ordinary alcohol, then 6 lb. of amyl alcohol; before making the mixture the insecticides are incorporated in the alcohol if they are insoluble in water, and in the soapy solution if they are soluble in the alkaline liquid. These preparations keep perfectly; when used they are diluted as circumstances may require. The different applications of these insecticides are detailed under Soap.

118. **Glycerine,** $CH_2OHCHOHCH_2OH$.—**Preparation.** — Glycerine is present in all natural fats chemically combined with fatty acids. It is a by-product of soap manufacture.

Use.—Glycerine is only mixed with insecticides and anticryptogamic solutions to increase their adherence to the leaves. It has been recommended chiefly by Mohr.

118a. **Ordinary Ether,** $C_2H_5 . O . C_2H_5$.—**Definition.**—Ordinary ether, erroneously termed sulphuric ether, is the oxide of ethyl.

Preparation.—To 7 parts of ordinary alcohol there is added, in the cold, 10 parts of concentrated sulphuric acid; the mixture is heated in a flask to 140° C. and 95 per cent alcohol is allowed to drop therein so as to keep the temperature constant. In these conditions alcohol is converted almost entirely into ether and water.

$$2C_2H_5OH = C_2H_5 . O . C_2H_5 + H_2O.$$

Properties.—Ordinary ether is a very mobile liquid, volatile, and of a penetrating odour. It boils at 35·6° C. It dissolves in 10 parts of water. [Highly explosive.]

Action on Plants.—An atmosphere saturated with ether vapour does not lower the germinative capacity of dry seeds, but it only requires a small quantity, 3·7 cubic centimetres per 10 litres of air (3·7 cubic inches per 10,000 cubic inches), to kill moist seeds. Ether favours the assimilation of the plant in an analogous manner to chloroform, but whilst it takes 0·5-0·7 of the latter to stimulate this function, ether acts favourably in 5-6 per cent doses. This action disappears when the ether is lower or higher than the figures indicated (Latham). There is also a fixed dose to stimulate the respiratory functions.

Use.—*Conchylis ambignella*, Hub. (cochylis of the vine); *Eudemis botrana* (eudemis or tortrix of the grape).—Audebert used with success against the caterpillars of these two butterflies the following liquid: Ordinary ether 10 lb., essence of absynth 1½ lb., ammoniate of copper 8½ lb., pure rosin 15 lb., carbonate of soda 15 lb., water 95

gallons. To prepare this liquid dissolve the rosin and the carbonate of soda in 6 gallons of water, boil until of a syrupy consistence, cool, remove the excess of liquid, redissolve in the necessary amount of water, add the ether and the essence of absynth, and when the mixture is homogeneous add the ammoniate of copper. The preparation should form a limped green liquid. This preparation is termed "Bordelaise insecticide". In 1902 more than 30 million stocks were treated with this insecticide, either by steeping the grapes or by a very fine jet. The amount consumed varies from 300-600 litres per hectare (26·4-52·8 gallons per acre). This preparation is recommended for the destruction of parasites in general, for it kills all caterpillars. Nobbe and Richter found that ether could replace carbon disulphide in the disinfection of the soil. They obtained by the disinfection of the soil by an ether emulsion a yield of 4·5 per cent higher than that of the untreated plot, and they attribute this favourable result partly to the stimulating action of the small amounts of ether retained in the soil.

119. Mercaptan, C_2H_5SH.—**Preparation.**—By distilling sulphovinate of soda on the water-bath in presence of potassium hydrosulphide.

Properties.—Mercaptan is a colourless liquid with a very unpleasant alliaceous odour, boiling at 30° C. (86° F.) and slightly soluble in water.

Use.—Mouillefert and Rommier tried mercaptan to exterminate the phylloxera; 10 drops of mercaptan in a 1-litre flask killed the phylloxera in two days; tried on the large scale, by distributing in six holes dug round the infested stocks, a mixture of 12·5 cubic centimetres of mercaptan and 37·5 cubic centimetres of tar, the effect produced on the phylloxera was almost *nil*.

120. Formic Aldehyde, HCOH **(Formol, Formaline).—Preparation.**—By the oxidation of methyl alcohol vapours at a high temperature. It is manufactured commercially by the following process, due to Trillat. Methyl alcohol is heated in a copper jacketed pan. The vapours disengaged, mixed with air, are oxidized by passage over fragments of coke heated to a dull red. The products are afterwards rapidly abstracted by a vacuum at a more advanced stage of oxidation. The commercial concentrated product contains 40-42 per cent of formic aldehyde. In medicine or agriculture this solution is called formol or formaline. Polymerized formol is also sold under the form of pastilles, which by heating disengage formol.

Properties.—Formol possesses a strong sharp odour; its vapour irritates mucous membranes, the conjunctive in particular. Formol is soluble in pure water up to 30 per cent, in presence of methyl alcohol up to 42 per cent. It has extremely remarkable antiseptic properties, much resembling those of corrosive sublimate. Like the latter it acts on albumen and arrests, by its contact, the movements and growth of micro-organisms.

Action of Formol on Plants.—Loew has pointed out its toxic action on plants, but formol does not appear to have this action in the doses in which it is used to combat plant diseases. Utilized almost

exclusively to disinfect seed for sowing, it is especially from this point of view that it has been examined. Its vapours have almost the same action as its dilute solutions. The action of 0·1-0·2 per cent solutions of formic aldehyde (0·25-0·5 of formaline) is hurtful both to cereal grains and leguminous seeds, for it retards germination (Kruger, Arieti, Niger). However, beet seeds suffer less. F. Bruning has examined the point, and got the following results with oats :—

TABLE LXIV.—*Showing Effect of Steeping Seed-Oats in Formol Solutions on Germination.*

Duration of Action in Minutes.	*A.*		*B.*	
	Germinative Capacity, Per Cent.	*Germinative Faculty, Per Cent.*	*Germinative Capacity, Per Cent.*	*Germinative Faculty, Per Cent.*
5	82	98	54	99
10	77	99	79	99
30	78	99	57	99
Untreated	—	—	80	98

A, seeds sown undried ; B, seed air-dried for twenty-four hours before sowing. These results show that a 0·3 per cent solution of formic aldehyde (= 0·75 per cent of formol) does not act on the germinative faculty but solely on the germinative capacity ; it therefore only retards germination without abolishing it. Cranefield has shown to what point the germinative capacity is diminished by treatment with formol, and has demonstrated the effect of the concentration of the formol bath (steep) on the latter.

TABLE LXV.—*Showing Effect of Twenty Minutes' Steeping in Formol Solutions of Various Strengths on the Germinative Capacity of Seed-Corn. Water = 94·5 Per Cent.*

Formic Aldehyde, Per Cent.	*Equal to Formol, Per Cent.*	*Germinative Capacity, Per Cent.*	*Formic Aldehyde, Per Cent.*	*Equal to Formol, Per Cent.*	*Germinative Capacity, Per Cent.*
0·1	0·25	91·0	0·2	0·5	74·0
0·112	0·28	89·5	0·252	0·61	73·0
0·124	0·31	87·5	0·5	1·25	31·0
0·144	0·36	88·0	1·0	2·50	12·0
0·164	0·41	88·5	—	—	—

Solutions of formol lower the germinative capacity of seeds the more formic aldehyde they contain. The following interesting table, giving the result of two series of experiments, proves that the injurious action of formol does not depend on the duration of the steep.

TABLE LXVI.—*Showing Effect of Duration of Steep in Formol Solutions on Germinative Faculty of Seed-Corn.*

Duration of Steep.	*Disinfectant.*	*Germinative Faculty.*	
		A.	*B.*
20 minutes	Solution of 0·25 per cent formol, 40 per cent	85	89
1 hour	,, 0·25 ,, ,, ,,	92	87
2 hours	,, 0·25 ,, ,, ,,	86·3	89
3 ,,	,, 0·25 ,, ,, ,,	88	93
24 ,,	,, 0·26 ,, ,, ,,	82	78
3 ,,	Pure water	93	90
Untreated	. . . .	95	92

If the seed-corn so disinfected be sown on the fields the effect of the treatment is visible during the first stage of germination, but after thirty days there is no difference. A 0·1-0·2 per cent solution of formic aldehyde, say 0·2-0·5 per cent of 40 per cent formol, may be used with impunity to disinfect seed-corn.

Action of Formol on Fungi.—The surprising properties of formol, its action on micro-organisms, were recognized and examined by Trillat. He determined that its bactericidal capacity equalled that of corrosive sublimate, and that its extremely diffusible vapours are endowed with the same antiseptic properties. He believes that its action results from its property of rendering albuminous matter insoluble; formol acting on the protoplasm of the bacteria hardens it instantly, and they are thus unable to continue their evolution. Bardet agrees that formol acts in the same manner as on gelatine, on the envelopes of bacteria and on the spores of fungi and renders them unfit to discharge vital functions. It has, on the other hand, been seen that corrosive sublimate acts in a similar manner on albuminous bodies. Numerous experiments made on different bacteria by Trillat, Berlice, Miquel, Aronson, Schmitt, Stahl, Wortmann, Fayollat, and others, show that a dose of 1 in 10,000 to 1 in 20,000 of formol generally suffices to sterilize culture media and to render bacteria sterile; it takes at least 1 in 1000 of formol to kill them. Penicillium fungi and aspergillus algæ behave similarly, according to the experiments of Trillat. A solution of 1 in 10,000, or the ambient air containing 1 in 20,000, prevents the development of young spores. These are the doses of corrosive sublimate recommended by Hitchcock, Carleton, and Wuthrich as sufficient to prevent the germination of the spores of different parasitic fungi. The action of formol on the spores of cryptogamic parasites ought, therefore, to be about the same as that of corrosive sublimate. Although the remarkable properties of formol were known since 1888, it was only in 1896 that Geuther tried to use this product in agriculture, and after fortunate results recommended it for disinfecting seed-corn in place of hot water or blue vitriol. The experiments made with this end in view show

that the dose of 1 in 10,000, which stops the development of spores for some time, does not suffice to completely disinfect seed-corn, and to prevent fungi from subsequently attacking the plant. Hecke observed as regards the spores of *Ustilago crameri*, that they only remained inactive for six to eight days after the treatment, and that the evolution of the disease was only retarded, which delay is often sufficient to guarantee the young plant. The dose of 1 in 1000 suffices, on the other hand, to disinfect the seed completely.

The following are, moreover, the results of different researches on this subject.

McAlpine has compared the action of blue vitriol, corrosive sublimate, and formol on the spores of *Tilletia* and obtained no infested ears (1) by immersion for one minute in a 2·4 per cent solution of blue vitriol; (2) by immersion for three minutes in a 0·12 per cent solution of corrosive sublimate; (3) by immersion for ten minutes in a solution of formic aldehyde 0·05 per cent (0·125 per cent of formaline), whilst the untreated plot gave 95 per cent of rusty ears. These doses thus completely disinfect seed-corn. Moore made the following experiments on oats and obtained :—

TABLE LXVII.—*Showing Effect on Oat Crop of Steeping Seed-Oats in Solutions of Formol of Different Strength and for Ten Minutes up to One Hour.*

Duration of Steep.	*Formol,* 100 *Per Cent.*	*Diseased Ears, Per Cent.*
10 minutes	0·1 (1 lb. formaline in 40 gals. water)	1
20 ,,	0·1 (,, ,, ,, ,,)	0
20 ,,	0·05 (1 ,, ,, 80 ,, ,,)	5
40 ,,	0·05 (,, ,, ,, ,,)	4·3
60 ,,	0·025 (1 ,, ,, 160 ,, ,,)	20·0

Hecke made the curious observation that it sufficed to wash the spores after treatment to redouble all their vigour. Spores of *Ustilago crameri* steeped fifteen minutes in a formol solution of 0·4 per cent and unwashed, did not germinate in thirty days, but they germinated normally in twelve days if washed after treatment. Treatment with formol even in large doses does not kill the spores if they are afterwards washed with water. The spores of *Ustilago crameri* are only killed by an immersion of one hour in a 1 per cent bath of formol or three hours in a 0·5 per cent bath of formol. To disinfect seed-corn and sufficiently retard the development of spores, an immersion of fifteen minutes in 0·4 per cent of formol, of one hour in 0·2 per cent, and three hours in 0·1 per cent suffices.

Action of Formol on Insects.—Insects withstand formol better than fungi; coccides are not killed by formol vapour after two days' action (Reh). Solutions are without action on plant lice (Klein), on the caterpillars of cochylis (Lustner).

Use.—*Oospora scabies*, Taxter (potato scab); *Rhizoctinia Solani*

(potato pox and rot of the stem of the potato); *Phytophthora infestans*, De By. (potato disease).—The spores of these fungi adhere to the seed potatoes and most often propagate the disease. To prevent this, the soil and the seed potatoes are disinfected by formol, and the results obtained were satisfactory. According to the experiments of Jones, Orton, Selby, and Arthur, disinfection by formol is as effective as by corrosive sublimate. The formol solutions recommended vary from 0·33-0·4 per cent of formol, say 0·16-0·13 per cent of formic aldehyde. Steeping should last two hours. The following is a convenient method of working according to Rolfs and Woods: Immerse the uncut tubers for two hours in a bath consisting of 4 lb. of 40 per cent formol in 100 gallons of water, dry them, convey them to the field in disinfected sacks and plant them. Tubeuf, Jones, and Morse recommend the disinfection of tubers by formol vapour generated by heating formaline pastilles in a closed space. Delacroix advises against *Bacillus solanacearum* the disinfection of the soil by a 0·13 per cent solution of formol in the proportion of 10-12 litres (2·2-2·64 gallons) per square metre and steeping the tubers for two hours in a solution of the same strength. Against *Rhizoctinia* of the asparagus disinfection of the soil with 60 grammes (about 2 oz.) per square metre. Potatoes so treated only gave 3 per cent of diseased stems, the untreated gave, on the contrary, 40 per cent.

Botrytis cinerea (grey rot of the vine).—Tubeuf recommends formol vapour in a closed space against this fungus. It is possible that on the large scale formol solutions would act energetically against this mould. If applied on grapes the moment the disease appears, the effect would, without doubt, be salutary, for Trillat has shown the energetic action of formol on the *Penicilium* mould, a closely allied species.

Microsphæra grossulariæ, Wallr. (gooseberry blight).—Close records that a formol solution of 0·08-0·12 per cent gives as good results as potassium sulphide. It is necessary to begin the treatment as soon as the disease appears.

Fusarium Dianthi, Pr. et Del.—Delacroix having found that formol vapours killed the *chlamydospores* of this fungus advised the disinfection of the soil by formol to prevent this disease.

Fusarium nov. sp., Bolley (flax disease).—Bolley obtained very good results by disinfecting the seed for sowing by immersion in a formol solution of 0·5 per cent (0·2 per cent formic aldehyde).

Tilletia and Ustilago (bunt and smut of grain crops).—The disinfection of seed-corn by formol was invented by Geuther. It is now recognized as far superior to the other methods. It results from numerous trials in this direction that 0·25 per cent formol solutions (0·1 per cent formic aldehyde) are strong enough and that fifteen minutes' immersion suffice to disinfect the corn-seed completely. By this treatment crops can be obtained without any diseased ears. It is essential not to wash the grain after treatment, for as Hecke has shown washing reimparts all their vitality to the spores and thus totally annuls the effect of the treatment. The seed is dried after immersion or planted immediately after simple draining and whilst still moist. Tubeuf and Neger have examined the disinfection of corn-seed in a

closed space by formol vapour and obtained the same results as with solutions, but the grain must remain at least five hours in an atmosphere containing formol. It suffices to heat a tablet of formaline on a spirit lamp, and close in the space. Bedford compared the action of bouillie bordelaise made from 2 per cent of blue vitriol and 2 per cent of lime with that of a formaline solution of 0·2-0·3 per cent. The results showed the superiority of the formaline.

TABLE LXVIII.—*Showing the Results of Growing Oats from Undisinfected Seed and from Seed Disinfected by 2 Per Cent Bouillie Bordelaise, and from Seed Disinfected by 0·2 Per Cent and 0·3 Per Cent Solutions of Formaline.*

Variety of Oats.	*Treatment.*	*Healthy Ears.*	*Diseased Ears.*
Mortgage Lifter . . .	*Nil*	249	29
Doncaster Price . . .	,,	365	49
Flying Scotsman . .	,,	392	52
Mortgage Lifter . . .	Bouillie bordelaise, 2 per cent	298	8
Doncaster Price . . .	,, ,,	322	32
Flying Scotsman . .	,, ,,	295	9
Mortgage Lifter . . .	Formaline, 0·2 per cent	386	0
Doncaster Price . . .	,, ,,	265	0
Flying Scotsman . .	,, ,,	298	0
Mortgage Lifter . . .	Formaline, 0·3 per cent	188	0
Doncaster Price . . .	,, ,,	255	0
Flying Scotsman . .	,, ,,	262	0

TABLE LXIX.—*Showing the Results of Growing Oats from Undisinfected Seed and from Seed Disinfected by 2 Per Cent Bouillie Bordelaise, and from Seed Disinfected by 0·2 Per Cent and 0·3 Per Cent Solutions of Formaline.*

Variety of Oats.	*Treatment.*	*Duration of Steep.*	*Sound Ears.*	*Diseased Ears.*
Doncaster Price	*Nil*	—	163	142
,, ,,	Bouillie bordelaise, 2 per cent	5 minutes	236	98
,, ,,	,, ,,	10 ,,	175	100
,, ,,	Formaline, 0·3 per cent	5 ,,	291	0
,, ,,	,, ,,	10 ,,	386	0
,, ,,	,, ,,	30 ,,	325	0

These results were submitted to a regular control in Canada, and found exact. Bedford considers that an immersion of five minutes in a formaline solution of 0·3 per cent suffices to guarantee crops completely against rust diseases. The seed is sown immediately after steeping. Selby recommends steeping seed-wheat infested with *Tilletia* spores first in water, then to remove the floating ones, then draw off the water and replace by a 0·2 per cent of formaline. Bolley advises a mixture of formol and corrosive sublimate as indisputably superior to all other disinfectants. It would always give good results.

Ustilago crameri (smut of millet).—Hecke examined the effect of different disinfectants on the spores of this smut. Millet being very sensitive to hot water, the latter cannot be recommended as treatment; disinfection by formol in 0·1 per cent solution is therefore of great importance.

TABLE LXX.—*Showing the Effect of Solutions of Formaline, Corrosive Sublimate, Oil of Vitriol, Blue Vitriol on the Germinative Capacity of Millet Seed and the Spores of Ustilago crameri.*

Treatment.	*Strength, Per Cent.*	*Duration of Action.*	*Effect on Seed.*		*Spores Germinated.*		
			Definitive Germination, Per Cent.	*Germinative Force, Per Cent.*	*After One Day.*	*After Two Days.*	*After Twelve Days.*
Formaline . .	0·25	2¼ hours	81·5	89	*Nil*	*Nil*	Some
,,	0·25	6 ,,	74·0	88	,,	,,	*Nil*
,,	0·5	2¼ ,,	72·5	87	,,	,,	,,
,,	0·5	6 ,,	67	84·5	,,	,,	,,
Corrosive sublimate	0·1	30 minutes	69	88	,,	,,	,,
,, ,,	0·2	30 ,,	69	88	,,	,,	,,
Sulphuric acid .	0·5	14 hours	79	83	A few	Great number	Great number
Blue vitriol . .	0·5	14 ,,	75·5	88·5	*Nil*	*Nil*	*Nil*
Untreated . .	—	—	74	89	Great number	Great number	Great number

To show the good effect of formol as a disinfectant, Hecke submitted a portion of seed millet to various treatments, and only collected for sowing the very rusty seed which floated. In these conditions he obtained in the open field the following result:—

TABLE LXXI.—*Showing the Effect of Certain Disinfecting Fluids on the Crop Produced from the Rusty Seed-Corn which Floats on the Fluid.*

Treatment.	*Strength, Per Cent.*	*Duration of Steep.*	*Number of Diseased Ears.*	*Diseased Ears, Per Cent.*
Sulphuric acid . .	0·5	14 hours	898	81·6
Blue vitriol . .	0·5	,, ,,	54	4·9
Formaline . . .	0·5	5½ ,,	11	1·0
Untreated . . .	—	—	1100	—

Hecke after many trials, which need not be discussed, believed in the efficiency of formol as a disinfectant for seed millet and in its superiority to the usual disinfectant if the grains are steeped for fifteen minutes in 0·5 per cent solution of formaline, or for one hour in 0·25 per cent solution of formaline, or for three hours in 0·125 per cent solution of formaline.

Ustilago Panici miliacci behaves like *Ustilago crameri.*

Urocystes Cepulæ, Frost (onion smut).—Selby made experiments to overcome this disease, and it was chiefly by formol and lime that he diminished it by introducing these products in the soil at the time when the onion is sown.

TABLE LXXII.—*Showing the Ac ion of Formol and Lime and Mixtures thereof on Onion Rust.*

Trea.ment.	*Rust Found.*	*Increase of Onion Crop, Per Cent.*
Quicklime, 33 bushels per acre	Much	32·3
,, 66 ,, ,,	A little	65·2
Formaline solution, 0·375 per cent	Very little	113
,, ,, 0·75 ,,	Infinitesimal	119
Quicklime, 1?0 bushels per acre	*Nil*	120·6
,, 66 bushels per acre Formaline solution, 0·375 per cent	*N.l*	132·8

The quantity of formaline of 0·375 per cent and of 0·75 per cent which is used varies from 4675-6540 litres per hectare (411 gallons per acre to 575·4 gallons per acre). The lime is regularly incorporated with the soil; before sowing the onions the formaline is run mechanically on to the seeds whilst the latter are being sown by the drilling machine.

Practical Method of Disinfecting Seed-Corn.—An 88-gallon vat is filled with water and about 1 quarter gallon of 40 per cent formol added. Two bags containing ½ cwt. of the grain to be disinfected are then placed therein. A man for fifteen minutes unceasingly turns the bags in the liquid in such a way that each bag comes in contact with the formol. The sacks are raised and allowed to drain on two bars laid over a low vat placed alongside the big vat. The grain is then placed on the floor of a heated spot and dried at a temperature not above 30° C. (86° F.), shovelling them until dry. By this method 4 metric tons of grain may be disinfected in a day with three vats and a floor of 20 square metres (24 square yards). Needless to say, drying may be done in the open air and in the sun when a proper space is not at disposal.

121. Acetic Acid, CH_3COHO.—**Preparation.**—Acetic acid results from the oxidation of ethyl alcohol. The acetification of the alcohol is due to its oxidation, under the influence of an aerobic ferment, *mycoderma aceti*, or mother of vinegar, and the oxygen of the air. It is prepared commercially by letting wine flow slowly into casks filled with wood shavings "sown" with mycoderma, and traversed from below upwards by a slight current of air. The alcohol oxidizes rapidly at 30° C. Acetic acid is also a product of the distillation of wood.

Properties.—Acetic acid is a colourless liquid soluble in water and alcohol, and boiling at 118° C. Vinegar, which only contains about 10 per cent of acetic acid, is used to preserve fruit.[1]

[1] *Translator's Note.*—The author here refers no doubt to the wine vinegar of France; the percentage in British malt vinegar is often less than half that given here.

Action on Fungi and their Spores.—Fungi spores are very sensitive to acetic acid (Wuthrich). Dilute acetic acid (0·06 per cent) still destroys the zoospores of *Phytophthora infestans*, De By., and acts very unfavourably on the germination of the conidia of *Peronospora viticola*, De By. The spores of *Ustilago carbo* do not germinate after steeping in acid of 0·06 per cent; the uredospores of *Puccinia graminis*, although very sensitive to a solution of 0·06 per cent, are only destroyed by acid of 0·6 per cent. The latter results agree with those obtained by Hitchcock and Carleton on *Puccinia coronata*. These spores do not germinate after steeping in acid of 0·1 per cent.

Use.—*Coryneum Beyerinckii* (gum of trees with stoned fruits, *Nectria ditissima*).—Muller advises to overcome the gum of fruit trees by the following treatment. After having removed the bark, scraped and planed the wound with the knife, a rag, drenched with 50 per cent acetic acid, is introduced into the wound and covered with a layer of grafting mastic.

122. Oxalic Acid, COOH . COOH.—**Preparation.**—By oxidizing wood sawdust mixed with a concentrated alkaline solution and heated to 250° C. (482° F.) in wrought-iron cylinders. The mass obtained is treated with water, and milk of lime added. Oxalate of lime is precipitated and collected on a filter. The precipitate is decomposed by dilute sulphuric acid, filtered, and the solution evaporated to crystallizing point.

Properties.—Oxalic acid forms white crystals soluble in 10 parts of water at 20° C. and in alcohol.

Action on Fungi.—The effect of oxalic acid on the spores of fungi has been examined by Wuthrich. This acid behaves very like acetic acid. The conidia of *Peronospora viticola*, De By., and of *Phytophthora infestans*, do not germinate in an oxalic acid solution of 0·063 per cent; the movements of the zoospores of this latter fungus are arrested, as well as their germination, by a 0·0063 per cent solution. The spores of *Ustilago carbo* behave like the conidia of *Peronospora*; however, the uredospores of *Puccinia graminis* are more resistant and are not killed by a 0·63 per cent solution.

Use.—*Nectria ditissima*, Tul. (canker of the pear-tree).—Ouvray advises the use of oxalic acid to overcome the canker of fruit trees. Clean the wound with a grafting knife, remove everything which is torn or destroyed, then rub the wound several times with sorrel or oxalic acid, then cover the wound with mastic or tallow to keep out the air.

Schizoneura lanigera, Hausm. (woolly aphis).—Oxalic acid appears to be a specific against this aphis, for many scientific observers, such as Taschenberg, Goethe, and Montillot, boast its good effects. It is as energetic as Nessler's insecticide. A solution of 1-1·6 per cent pure or mixed with a little soft soap, is used with the brush on the colonies of woolly aphis, for the first time in autumn after the ripening of the fruit, a second time eight to ten days later, and a third time in the spring.

CHAPTER XX.

CARBON COMPOUNDS (*continued*)—OILS AND FATS—SOAPS—HARD SOAP —SOFT SOAP—WHALE OIL SOAP—FISH OIL SOAP.

123. Natural Fats.—Preparation.—Oils and fats are chemical compounds of glycerine and fatty acids. They are found, in nature, both in plants and in animals. They are extracted either by hot or cold pressure between plates, or heated millstones, or by an appropriate solvent—ether, carbon disulphide, chloroform, benzine, petroleum spirit, etc.

Properties.—Oils are insoluble in water; they oxidize in the air, resinifying in so doing.

Colza oil, extracted from seeds of *Brassica campestris*—D. = 0·913 at 15° C., solidifies at 6·2° C.

Poppy oil, extracted from seeds of *Papaver somniferum*—D. = 0·925, congeals at 19° C.

Olive oil, obtained by hot crushing of ripe olives—D. = 0·919 at 12° C., congeals above 0° C.

Linseed oil, extracted from the seeds of *Linum usitatissimum*, has a density of 0·939 at 12° C.

Whale oil, extracted from certain organs of the whale—D. = 0·927, concretes at 0° C.

Action on Plants.—Vegetable respiration being carried on in the leaves, these organs should remain in contact with the air so that they may fulfil their physiological functions. The application of oil on the leaves is therefore injurious to the plant. The pure oils themselves, applied uniformly on the trunk of a tree, have an injurious effect on the health of the plant. Mouillefert found, in fact, that young vines are killed if the greater part of their roots are covered with oil.

Action on Insects.—Although the action of oil on insects is mechanical, they are as efficient as poisonous insecticides. The oil penetrates everywhere, and by invading the respiratory organs asphyxiates the insects. Eggs covered with a layer of oil also die, because the exchange of gases through the membrane of the egg can no longer be carried on.

Use.—Oils are used in the pure state or as emulsions with pure or soapy water. The emulsions are prepared like emulsions of petroleum with water.

Silpha opaca (beet carrion beetle).—Brocchi overcomes the ravages of this insect in the North by an emulsion of soft soap 1 lb., rape oil or poppy oil 15 lb., water 84 lb. Fouquier d'Herouel describes

its good effects when sprayed on and between the plants to be protected. One workman treats a hectare ($2\frac{1}{2}$ acres) in nine hours.

Atomaria linearis, Steph.—This parasite is overcome in the same way as the beet silph.

Conchylis ambignella, Hubn. (cochylis of the vine).—Roy advises to asphyxiate the caterpillars of this butterfly by dropping one to two drops of colza oil in each of the silky nests. Muth describes the excellent results obtained against these caterpillars at the Oppenheim School of Viticulture by the use of olive, sesame, and colza oils. The lantern traps in use in Switzerland, for trapping butterflies at night, are surrounded with a plate which contains a bird-lime consisting of white pitch 10 lb., linseed oil 5 lb., olive oil 6 lb., turps 5 lb. Debray advises to bark the tree with the Sabate glove, and then to coat them with oil extracted from sulphuretted colza oil cakes [? by carbon disulphide]. It takes 1 litre of oil for twenty stocks.

Caterpillars and Eggs of Lepidoptera.—Oils and their emulsions with soapy water are, in general, of indisputable efficiency on caterpillars and eggs, and are employed in many cases. Saunier recommends an emulsion prepared in the following way: Dissolve 2 grammes of carbonate of soda in 1 litre of water, and then add 30 grammes of linseed oil; stir until formation of a homogeneous emulsion. The nests of the caterpillars are sprayed by a hand syringe or by a spraying machine. The eggs deposited on the surface of the branches are destroyed by coating with the pure oil.

Formica (ants).—Oil emulsions are used to destroy ants: Oil 30 lb., carbonate of soda 5 lb., in 100 gallons of water, or better still, olive oil alone. It is especially used to destroy the ants which climb along the branches and trunks of trees (Taschenberg).

Gryllotalpa vulgaris (mole cricket).—Ratzeburg in 1847 advised to inject oil into the tunnels of the mole cricket and to sprinkle with water. Before the preparation of the beds, whilst the bed is bare, the tunnel openings are inspected and a few drops of oil run into each, then water from a water-can.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—Mouillefert has shown that colza, poppy, olive, and nut oils kill the phylloxera by contact with the greatest of ease. Their use cannot, however, be adopted on the large scale, as they kill the plant too readily.

Pollier's process (1872) against phylloxera, which consisted in coating the stems with an emulsion of whale oil and petroleum, did not give satisfactory results.

Aphides (green lice).—To kill the eggs of these green lice deposited in lichens along the trunk or on the end of branches it suffices, according to Taschenberg, to rub these spots with oil.

Schizoneura lanigera, Hausm. (woolly aphis).—Oils are especially used to destroy this aphis, as they easily penetrate its wool and asphyxiate it. The oil should only be applied to small surfaces, nodes, cankers, holes. Muhlberg advises to coat the cankers with fish oil, with burning oil, or a mixture of burning oil and petroleum. Muhlers advises to brush the hotbeds of infection with oil or fat, and to repeat this treatment every fifteen days. Cirbert advises to rub the infested

places with a rag dipped in olive oil. Oil is currently used in Italy against this aphis. Weiss advises to cut out the cankers and to treat them with insecticides, and then to cover the wounds with oil paint, which kills by asphyxia any aphis which might escape, and which protects the wounds very efficiently. Henri advises to drench the swellings on the trunk and the branches with a mixture prepared in the following manner: Crush together alum 5 oz., sal ammoniac 5 oz., and mix with sulphuric acid 3 oz., colza oil 100 oz. (all avoirdupois). According to Kraft, it suffices to plug the wounds produced by the woolly aphis with a mastic made by mixing plaster of paris and linseed oil. Ouvray recommends as an excellent medium for destroying the woolly aphis, burning oil, in which 5 lb. of naphthalene has been incorporated per 10 gallons. At the fall of the leaf the diseased apple-trees are brushed, the nodosities cut off, and coated with the naphthalinated oil, taking care not to touch the buds. In March or April the tree is again inspected, and if need be, the spots recently invaded are plugged with the naphthalinated oil, applied by the brush.

Coccides (cochineals).—Cochineals, kermes, etc., may be killed in the same way as the woolly aphis, by oils and their emulsions with soap, or with petroleum. It is only to be feared that the too large surfaces, which it is often necessary to cover, may render the treatment injurious to the plant. This drawback disappears, according to Reh, if the oils are used as emulsions with soap or petroleum. Excellent results are got, according to him, with an emulsion of soft soap 20 lb., vegetable oil 15 lb., petroleum 10 lb., water 6 gallons. In America the San Josė louse is overcome with whale oil and fish oil.

Lepus cuniculus, L. (rabbit); *Lepus europæus*, L. (hare).—Putrid fish or animal oil protects crops and fruit trees. The bottom of the tree may be coated, or the property surrounded by a fence consisting of three cords dipped in this stinking oil, placed 8 inches from each other. The commercial preparations known as "Lapintine," "Pomoline," "Picrofoetidine," consist of these oils. The leporides fear this strong smell, much resembling the smell of its natural enemies, the ferret, the martin, and the fox.

124. Soaps are salts formed by the combination of a base with the fatty acids present in oils and fats. All vegetable and animal oils and fats yield soap with alkalies, and with metallic oxides generally. Their physical properties depend chiefly on the base used. Soaps made from alkaline metallic oxides are alone soluble in distilled water; those made from the oxides of other metals, lime or copper soap, for example, are, on the contrary, insoluble in water. Amongst soaps made from alkalies, hard soda soaps must be differentiated from soft potash soaps.

Preparation.—1. *Hard Soaps.*—They consist generally of the soda salts of margaric [palmitic], stearic, and oleic acids; *Marseilles* soap is the type of this sort. It is made by saponifying vegetable oils with caustic soda. Glycerine is formed along with the soap, and is eliminated in the mother liquor. In a large wrought-iron pan caustic soda lye of 10° B. is heated, and the oil to be saponified run in gradually. When the bulk is combined, the saponification is finished by adding lye of 20° B. Boiling is continued until the whole is homogeneous. The

soap is then separated from the water by adding weak salted lye. The soap which floats is separated from the mother liquor. After complete boiling in fresh salt lye, the preparation of the soap is finished.

2. *Soft Soaps.*—They consist of the potash salts of the most diverse fatty acids, for all oils are used in their preparation.

(*a*) *Whale Oil Soap.*—The salt of doeglic acid of whale oil. This soap is gelatinous, and but slightly soluble in water.

(*b*) *Fish Oil Soaps.*—The oils obtained by boiling decomposing herrings and other sea fish are much used in America for the preparation of soap intended to be used against parasitic fungi. Sixty pounds of caustic potash are boiled in 100 gallons of rain water, and 19 gallons of cod oil or herring oil. After two hours' boiling, the soap is finished. The soaps obtained are semi-solid.

(*c*) *Black Soap, Green Soap.*—These have a very analogous composition, they are the ordinary soft or potassic soaps. These soaps are gelatinous and soft, containing a great excess of lye and almost all the glycerine. They are thus very caustic, and act like feeble alkalies. They are obtained by boiling caustic potash chiefly with linseed, colza, and hemp-seed oil soap. The solutions are evaporated to a suitable consistency. American arboriculturists prepare a cheap and efficient soap by boiling together in 10 gallons of water, 12 lb. of lard, and 12 lb. of carbonate of potash. During boiling a milk of lime containing 5 per cent lime is added. Before using it to coat trees 1 part of it is diluted with 2 parts of hot water. The bark of the trees covered with this soap always remains fine and smooth.

Insecticide Preparations.—Soap strengthens the action of certain insecticides. It is thus often mixed with the most diverse organic insecticides to form preparations capable of drenching the insects and bringing the poisons in contact with them better than aqueous solutions do. Soap emulsions are made with petroleum, benzine, carbon disulphide, and mixtures with ethyl alcohol, amyl alcohol, and quassia.

Composition and Preparation of a Few Insecticides.—1. Macerate in water for twenty-four hours 1½ lb. of quassia; boil and mix the extract with 2½ lb. of soft soap in 10 gallons water (Taschenberg).

2. Pour 2 gallons of boiling water on 3 lb. of quassia chips, macerate twenty-four hours, add 5 lb. of soft soap in 2 gallons water.

3. Emulsify 1 lb. of soft soap in 20 gallons water with 1 lb. carbon disulphide.

4. Emulsify 1 lb. of soft soap in 20 gallons water with 1 lb. petroleum.

5. Emulsify 1 lb. of soft soap in 20 gallons water, 1 lb. carbon disulphide, and 1 lb. petroleum.

6. Emulsify 5 lb. amyl alcohol, 5 lb. of a concentrated alcohol solution of soap, 10 lb. of carbon disulphide, and 5 lb. of petroleum, in 100 gallons water.

Emulsions Nos. 3 to 6 have been used with success at the Phytopathological Institute of Pisa.

7. Dissolve 3 lb. of soft soap in rain water, add 6 lb. of amyl alcohol, and make up to 10 gallons with rain water

8. Dissolve 5 lb. of soft soap in $6\frac{1}{2}$ gallons of water, add thereto 2 gallons of ordinary 90 per cent alcohol and 1 gallon of amylic alcohol.

9. Infuse 3 lb. of tobacco for some time in 5 lb. of amyl alcohol, and 2 lb. of ordinary alcohol; add a solution of 4 lb. of soft soap, then make the whole up to 10 gallons (Muhlberg).

These emulsions cannot be further dwelt upon here, each one will be described under the heading of the insecticide with which it is mixed.

Action of Soap on Plants.—Soaps are more injurious to trees the more caustic alkali and alkaline carbonates they contain. Solutions of Marseilles soap (hard soap) are less injurious than soft soap; the latter becomes injurious, according to plant treated, from 0·66 per cent; it is dangerous to flowers from 1·32-2·5 per cent, for soapy sprayings prevent them from producing fruits; finally, it attacks the skin of stone fruit, and injures the leaves when tender. Used in winter of great strength (18-24 per cent) soap renders the trees sterile; this is not the case with 6-12 per cent solutions, except for the peach. Mixtures of soap and alcohol are slightly more injurious than aqueous solutions of soap, and when concentrated may kill the tree, but it is more especially mixtures containing tobacco which are dangerous and should be used with care.

Action on Insects.—Soap in solution acts energetically on soft-skinned insects and their larvæ. A 2 per cent solution acts on caterpillars, larvæ of wire-worms, etc. Strong solutions of soap also act on protected insects, such as the cochineals. Marlatt found that, used on trees in winter, a 24 per cent solution of ordinary white soap killed more than 97 per cent of the San José louse; an 18 per cent solution killed more than 95 per cent; a 12 per cent solution more than 90 per cent; a 6 per cent solution more than 20 per cent; and a 3 per cent solution more than 10 per cent. Fish oil soaps are less energetic. An 18 per cent solution only kills 50-75 per cent; and a 12 per cent solution only 20 per cent. Whale oil soap solutions of 20-30 per cent kill 90-100 per cent of San José louse. In these mixtures soap whilst an insecticide, generally only acts by bringing the parasites in better contact with the insecticide and by increasing its adherence.

Use.—To dissolve the soap, or dilute preparations containing soap, it is well only to use rain or distilled water, to prevent the lime of ordinary water from precipitating lime soaps, which encrust the spraying machines.

Cryptogamic Diseases.—*Sphærotheca pannosa* (rose mildew).—To overcome this fungus use a 2 per cent solution of soft soap (Vesque).

Mildew of Phlox Drummondii and of Verbenas.—Halsted and Kelsey overcome this disease by a solution of 3 lb. of rosin [? soap] in 10 gallons of water. The plants were sprayed twenty-six times from 27 November to 1 April. The action of an emulsion of petroleum 3 gallons, rosin soap 2 lb., water 100 gallons, was much more efficient, even when diluted three times further.

Insects.—*Tomicus dispar*, *Bostrichus dispar* (the apple bark

beetle).—To destroy eggs of this insect deposited on the trunk of fruit trees and branches a 25 per cent solution of soft soap is used in Canada.

Oryctes nasicornis, L. (rhinoceros).—To destroy larvæ, water soil around stem with 2-3 per cent solution of soft soap (Targioni-Tozzetti).

Elaterides (wire-worms).—The larvæ are killed by 2-3 per cent solutions of soft soap.

Phoeotribus liminaris (Harris).—Attacks bark of peach-trees in Canada. To overcome it use a soft soap solution to which the consistency of a thick oil has been given by carbonate of soda in strong solution (Fletcher).

Silpha opaca (beet carrion beetle).—To overcome this insect use a mixture of equal parts of amyl alcohol and soft soap, diluted to produce 1-2 per cent solutions of soap, which must be sprayed on the beets.

Crioceris Asparagi (the asparagus beetle).—The larvæ which live on the surface of the leaves of the asparagus is killed by Nessler's insecticide (formula 7) without injuring the plant. Sprayings, if need be, are repeated in the summer.

Pieris Rapæ, L. (small white cabbage butterfly); *Pieris Brassicæ* (large white cabbage butterfly).—Alvood advises to kill these caterpillars injurious to cabbage by spraying the cabbage with 6 per cent solutions of soft soap.

Gastropacha neustria (the lackey or barred tree lackey moth).—The caterpillars which shelter at night in a nest of gauze, which they spin, are dislodged by soap solutions and killed afterwards by various methods.

Conchylis ambignella, Hubn. (cochylis of the vine); *Eudemis botrana* (tortrix of the grape).—Soft soap is an excellent product for destroying the caterpillar of the cochylis. In 1896 a circular of the Italian Minister of Agriculture recommends the use against cochylis of pure soft soap solutions, say mixtures of soft soap and alcohol, or of soft soap and benzene. A 3 per cent solution suffices (Del Quercio); 2 per cent, according to Passerini. Dufour recommends a soft soap solution, with which a little tobacco juice has been incorporated. In the laboratory this solution, concentrated to 10 per cent, kills all caterpillars, but it is too strong to be used on the vine. On the latter a solution stronger than 4-5 per cent of soap must not be used. According to Petrobelli treatment with soft soap has, however, a deadly effect on the flowers and the grapes. When the sprayings are abundant a coating forms on the grape, which ends by burning the skin; when there is little liquid a drop accumulates at the lower part of each fruit, which, in concentrating, attacks the skin, which tears at that spot. Petrobelli likewise accuses this insecticide of giving a bad taste to the wine.

Hyponomeuta malinella, Zell. (small ermine moth of the apple).—Nessler's insecticide is used to combat the caterpillar of this butterfly hid in its silky nest.

Gryllotalpa vulgaris, Latr. (mole cricket).—Corot kills the mole cricket thus: Before tilling the soil it is well raked to render the

surface clean and neat; the earth is then beaten, watering it if need be. During the night the mole crickets dig new tunnels, which are seen the next morning. The fresh tunnels are opened with the finger and tepid soapy water poured in from a watering-can.

Formica (ants).—Soap is used against ants infesting trees.

Eriocampa adumbrata, Kl. (saw-fly of the slug-worm or slimy caterpillar).—Nessler's insecticide (formula 7, p. 328) is an excellent medium to kill the slimy caterpillar.

Blissus leucopteris, Say.—This bug, injurious to gramineæ, is destroyed by spraying with soap solutions (Quaintance).

Phyllobius oblongus (coleoptera injurious to the pear).—Horfer recommends abundant spraying with a 1 per cent solution of soap.

Aphidæ, (plant lice).—To destroy green lice in general Ducloux recommends two bouillies: (1) Soft soap 5 lb., tar 15 lb., water 2 gallons; (2) Tobacco extract 2-3 gallons; soft soap 5-10 lb., methyl alcohol 1 gallon, carbonate of soda 5 lb., water 100 gallons.

Aphis Papaveris.—Killed by a few sprayings with 5 per cent soap solution (Noel).

Aphis Rosæ, L. (rose aphis).—Green lice, as well as all unprotected lice, are readily destroyed by pure soap solutions and insecticide mixtures with a soap basis. Not being covered with a protective down like the woolly aphis, and living on the surface of the plant organs from which they draw their nourishment, they are far more accessible to insecticides, and resist them less. The solutions should be diluted so that neither the soap nor the insecticide injure the foliage. Solutions of 2 per cent of soap produce the desired effect. Lowe considers that 1·5 per cent of whale oil soap is better than all the other methods, if used as a spray, as soon as the lice appear on the young leaves. As winter treatment to kill the eggs or the adults in their refuge, a 50 per cent solution of soft soap may be used, according to Taschenberg. Many mixtures are recommended to replace solutions of pure soap; those consisting of quassia and tobacco, and diluted with water so as to contain 1·5-2 per cent of soap, *vide supra*. Delacroix recommends 1 lb. of carbonate of soda, 2 lb. of soft soap, in 10 gallons of water.

Schizoneura lanigera, Hausmann (woolly aphis).—Soft soap is used alone and incorporated with insecticides to kill the woolly aphis because it penetrates the down of white wax which protects the adult and allows the insecticide to act by contact. The U.S.A. Agricultural Department recommends a 6 per cent solution of soft soap. Muhlberg records the bad result obtained with a 7 per cent solution of soft soap, whilst Goethe found a 5 per cent solution very efficient. The season when the soap solutions are used evidently exercises an important influence that explains the different results obtained with the same product, for it is asserted that the young larvæ not coated with down, hatched in November or December, are very sensitive to insecticides, whilst the adults, owing to the agglomerations which they form, often escape the action of the most energetic insecticides. It is thus well to choose the most propitious time for treatment, November and December. At that time they may be successfully destroyed by

solutions of 3·3-5 per cent of whale oil, a dose which has no action on adults. Mixtures of soap and insecticides have a more decided and radical action, but they also must be applied at the time when the delicate larvæ issues from the winter egg. This moment varies with the different plant lice to such an extent that the time of treatment must be varied according to the species which it is desired to exterminate. One of the most energetic insecticides, and also the least injurious to trees, is that recommended by Nessler, consisting of soft soap, ethyl, and amyl alcohol: Dissolve 5 lb. of soft soap in $6\frac{1}{2}$ gallons of rain water, add, after cooling, 2 gallons of ordinary 90 per cent alcohol and 1 gallon of amyl alcohol. A mixture of 3 lb. of soft soap and 6 lb. of amyl alcohol in 10 gallons of water acts similarly. These insecticides are applied by the brush, such as they are, in winter during the hatching of the eggs, on all the nodosities and cankers produced by this aphis. It is well to prune the tree and to clean the trunk and the large branches before treatment; then the whole tree is sprayed with a solution diluted with an equal part of rain water. Summer treatment with this insecticide is not sufficient to kill the adult. Sorauer recommends a mixture of 50 oz. of soft soap, 2 oz. of carbon disulphide, and $6\frac{1}{2}$ gallons of water. Muhlberg recommends a mixture with tobacco: 3 lb. of tobacco, 5 lb. of amyl alcohol, 2 lb. of ordinary alcohol (formula 9, p. 329). If this last preparation infallibly kills the louse it also injures the buds and the leaves, especially when growing, whilst mixtures of alcohol and soap of equal strength have not this drawback.

Coccides (cochineals).—All cochineals are exterminated like the *Aspidiotus perniciosus*, Comstock (San José louse). Cochineals with a protective shield resist soap solutions, even concentrated, and insecticide mixtures containing soap, better than plant lice. As with the woolly aphis, it is best to attack the larvæ at the moment they are hatched, and when they issue from the protective shell of the dead mother. Pure soap solutions used against the San José louse some days before the fall of the leaf and a little before flowering, in the spring, were found quite satisfactory by Marlatt and Smith. As already seen the former obtained with a 24 per cent solution more than 97 per cent of dead cochineals. Smith, with whale oil soap of 20-30 per cent, up to 100 per cent of killed; with 20 per cent of white soap, strengthened by a little carbonate of potash, 85 per cent. Whale oil soap is the most energetic of all; it is now considered as a specific against cochineals. A tepid solution of soap applied on the young larvæ in spring kills them. (He experimented on the cochineal of the rose laurel.) A hot solution was used with success by Frank and Kruger. It is necessary to repeat this last treatment until the cochineals are exterminated. Unfortunately the soap solution to be effective must be applied of such a strength that it always injures the tree. Winter treatment with 18-30 per cent of soap always diminishes the blossom; flowering often does not occur at all; the peach is peculiarly sensitive thereto. This drawback may be avoided, according to Alvood, if the treatment be only applied in spring, after the formation of the fruit-buds and at the time of their swelling; they are then not so sensitive to the action of soap. Smith

found that a 5 per cent solution of whale oil soap was quite sufficient to kill the larvæ of all species of cochineals, whilst the young and the adults still resist. Ritzema Bos believes that cochineals can only be exterminated by destroying the larvæ. With dilute solutions applied even in summer on the trunks, the drawbacks resulting from the use of concentrated solutions are obviated. Solutions of soap and amyl alcohol, those which contain insecticides, are all used for the destruction of cochineal; they behave like solutions of pure soap but act in weaker solutions.

Thrips cerealium (thrips of grain crops).—Quaintance advises spraying with 0·5 per cent solution of whale oil soap.

Tetranchus telarius (red spider).—Stone, Fernauld, and Waugh recommend a mixture of sulphur and soapy water to destroy this acarus.

CHAPTER XXI.

CARBON COMPOUNDS (*continued*)—PRODUCTS OF THE AROMATIC SERIES—BENZOL—COAL TAR—WOOD TAR—NAPHTHALENE.

125. Benzene, C_6H_6. —**Preparation.**—Benzene or benzol is extracted from the tar from the distillation of coal. The products of the distillation are separated by fractional distillation.

Properties.—Benzene is a colourless, mobile liquid with a peculiar odour, boiling at 80° C.; its density is 0·880 at 20° C. Benzene is soluble in alcohol and carbon disulphide; it is insoluble in water. It dissolves fats and various resins. Absorbed by man, it produces a rather dangerous drunkenness. As an injection it produces rapid anesthesia followed by cramp.

Action on Plants.—Pure benzene has a corrosive action on plants; a drop placed on a cabbage leaf makes a hole there in a few days. Blazek examined the action of benzene vapours on the living vegetable cell and found an abnormal division of the nucleus, generally into four without membranous separations. Nemec found the same degeneration of the cells of *Vicia fabia* by a 1 per cent solution of blue vitriol. When cells so modified by the vapour of benzene are placed in a pure atmosphere, the division disappears and the cell becomes normal. The action of benzene would thus appear to be unfavourable to the normal evolution of the plant, but this action is only fleeting and disappears with the cause which produced it. Benzene as a proposed substitute for carbon disulphide has the great advantage over the latter of being less injurious to the plant and its roots. The maximum dose borne by a vine in a 4-litre pot is 20 cubic centimetres emulsified with 20 cubic centimetres water. Trials on haricots and weeds show that benzene does not kill plants except in comparatively large doses. Beans stand, as a maximum dose, up to 10 cubic centimetres per 2 litres of earth (10 in 2000); weeds only have the edges of their leaves dried when ½ gramme of benzene is incorporated per litre of earth in the soil.

Action on Insects.—Benzene kills insects by contact and by its vapours. Mouillefert examined its action on phylloxera and found that dipped in benzene the phylloxera and its eggs were killed in five minutes.

Use.—It has been proposed to substitute benzene for carbon disulphide against the larvæ of the lamellicorns, although the experiments of Mouillefert, in 1876, had shown that it was incapable of fulfilling this rôle against the phylloxera. It has, compared with carbon disulphide, the triple advantage of (1) cheapness; (2) diffusing more slowly in the soil when it is used with the pal injector; (3) of being much less injurious to the roots of plants. In spite of its

properties it does not replace carbon disulphide, except in isolated cases, and it can never render the same services as the latter. Its preponderating advantage over carbon disulphide is that it has a more prolonged action, especially in warm, dry weather. Benzene is also used in emulsions against aerial parasites, either pure or mixed with other insecticides. Debray records the good effect of an emulsion consisting of benzene 2 lb., ordinary alcohol $\frac{1}{2}$ lb., soft soap 3 lb., in 10 gallons of water; and a solution of naphthalene in 8 parts of benzene.

Melolontha vulgaris, L. (cockchafer).—The benzene from gas-works destroys the white-worm. Mohr advised its use as far back as 1893. Ritzema Bos records the good results obtained by treating fields in Holland, Taschenberg those obtained in the neighbourhood of Trieste, and Croisette-Desnoyers in pine plantations. Injections of benzene into the soil are made by the pal injector, like those of carbon disulphide. The nature of the soil, as well as the season, decides the number of holes and their depth. Thus holes are made of 8-10 inches intervals in light soil and 6-8 inches in heavy soils; the larvæ of the cockchafer living, according to the season, at different depths, the depth of the holes with the pal must be varied with the position occupied in the soil by the white-worm. The depth varies from 12-28 inches. The precautions to take are described under carbon disulphide. The amount of benzene to use per hole is 5 cubic centimetres. Fields of lupines only receive one injection per square metre. In pine plantations Croisette recommends to make injections every 70 centimetres (say 28 inches), and two to three injections a year. The results obtained in young plantations which suffer much from white-worm are perfect, and the treatment in no way injures the trees. Benzene has often given favourable results where carbon disulphide has failed. These doses sufficient to overcome the lamellicorns never injure the plant.

Cetonia stictica.—Ritzema Bos and G. Staes advise to destroy it to inject 5 cubic centimetres into dunghills every 8 inches by the pal injector. The benzene destroys the larvæ.

Elaterides (wire-worms).—Ritzema Bos found that wire-worms, the larvæ of the elaterides, resist benzene injections.

Othiorhynchus sulcatus (vine weevil).—Benzine has been recommended by Mohr in sprayings round the stocks with the view of destroying the larvæ of this weevil. Ritzema Bos regards it as inert in this instance.

Ceutorhynchus sulcicollus (cabbage weevil).—Mohr advises to combat it with benzene. As soon as the plants have five leaves, holes are made 8 inches around the plant, 8-12 inches in depth, and 5 cubic centimetres of benzene run into them and the holes closed up forthwith. The adult insect may also be exterminated by spraying with a soapy water emulsion of benzine.

Molytes coronatus (carrot weevil).—To destroy larvæ which attack fleshy part of carrot, Mohr makes round holes round young carrot 4 inches deep, into which he pours 5 c.c. of benzol and fills up at once.

Saperda carcharias, L. (*Saperde chagrinée*).—To destroy the caterpillars in their burrows, chloroform, turps, and benzene are used. Benzene is preferable. De la Blanchère operates thus: By means

of a gouge 1 centimetre ($\frac{2}{5}$ inch) in diameter the workman widens and enlarges each hole, which is hidden in the folds of the bark and under the moss of the lichens, but the presence of which is revealed by detritus resembling moist sawdust. He cuts the edges neatly, and quickly introduces into the hole a small hook, by means of which he draws out the detritus which blocks up the entrance to the burrows. The orifice being cleaned and in perfect communication with the burrows, the workman introduces, by means of a small needle, taking care not to press them, two or three plugs of cotton previously steeped in benzene. He forthwith closes the hole by means of a plug of rather stiff Roman cement, which he applies with a small trowel in such a way as only to penetrate into the hole to a small depth and to cover the edges with several centimetres of cement. The latter hardens rapidly and the hole is hermetically closed. The benzene in volatilizing fills the burrows with its vapours and asphyxiates all the creatures living therein. When the button which forms round the wound has repulsed the cement, the odour still suffices to keep off insects until the wood recloses of its own accord. An inspection every fortnight after applying this process assures the destruction of all the generation of the preceding year. The trees so freed do not suffer from the treatment, heal rapidly, and regain their vigour.

Cossus ligniperda, L. (the goat moth).—The process described for exterminating the larvæ of the Saperdas may be successfully used for that of the Cossus. To prevent the females from laying their eggs on the trunk, Truelle advises to coat it with a concentrated solution of green vitriol, or with a mixture of cow-dung and clay.

Zeuzera Aesculi (the wood leopard moth, horse chestnut Zeuzera); *Trochylium apiforme*, L.—The caterpillars of these two butterflies are combated like the larvæ of the Saperdas.

Agrotis segetum (the common dart moth).—According to Ritzema Bos, the grey-worm is exterminated by benzene in the same way as the white-worm and with full success. The caterpillars of an allied species, *Agrotis valligera*, very injurious to pine-trees, are exterminated in the same way.

Conchylis ambignella, Hubn. (cochylis of the vine); *Eudemis botrana*, Schiff. (eudemis or tortrix of the vine).—The Italian Minister of Agriculture recommends an emulsion of soft soap 3 per cent, alcohol 0·5 per cent, benzene 1·5-2 per cent. Debray obtained good results with this emulsion.

Lopus sulcatus (Grisette de la Vigne, Margotte). — Benzene emulsions are used as sprays, according to Pratigeon, for the destruction of the larvæ of this bug at the time when they are still on the charlock and groundsel at the foot of the stems. The adults are thus prevented from getting on the vines.

Tipula oleracea (crane-fly, known in England as gaffer longlegs and in Scotland as daddy longlegs).—The larvæ, injurious as much to the roots of strawberries as to salads and spinach, may be destroyed by shallow injections of benzene into the soil. It suffices that the injections be 1 centimetre from the plant, that they do not hurt it.

Tingis Pyri (tiger beetle of the pear-tree).—According to Taschen-

berg and Caruso an emulsion of 1 per cent benzene and 1 per cent soft soap is the best way to destroy the tiger beetle and the least injurious to the pear-tree.

Pulvinaria Vitis, Coccus Vitis (vine scale, vine cochineal), Targioni-Tozzetti (phylloxera of the vine).—Benzene destroys all the phylloxera on the roots of the vine in pot, but has proved itself inefficient on the large scale according to Mouillefert. A stock stripped received $\frac{1}{2}$ litre of benzene emulsified in 10 litres of water; the greater part of the phylloxera were destroyed it is true, but the roots at a great depth still bore numerous living lice. Benzene cannot therefore, it would appear, replace carbon disulphide.

126. Tar.—Tar is the liquid product which results from the dry distillation of coal and numerous organic bodies. Its nature varies with the raw material which gave it birth, but it is always oily, viscous, of a dark colour, and empyreumatic odour. Tar is insoluble in water.

1. *Coal Tar.*—Coal tar is a by-product of gas manufacture. It consists of a mixture of some fifty organic compounds, amongst which are benzene, toluene, naphthalene, and phenols. It is a black viscous liquid.

2. *Wood Tar.*—Wood tar is obtained by the dry distillation of wood. It is a by-product in the manufacture of pyroligneous acid and wood charcoal, also in the distillation of pines after the extraction of the turpentine. When it is desired to obtain tar chiefly, the distillation is slackened and 18 per cent of tar may be obtained in that way. The nature of the tar varies with the nature of the wood and the method of extraction used. Tar obtained by carbonizing wood has neither the same composition nor the same appearance as that obtained by distillation. The first is black and approaches coal tar; it contains a large amount of naphthalene. The second is pale, almost viscous, and contains paraffin. The composition of wood tar is thus more complex than that of coal tar. It contains benzene, toluene, styrolene, naphthalene, phenols, guaiacols, creosote, and other aromatic compounds. Tar is used in human therapeutics as an antiparasitic agent.

Action of Tar on Plants.—Tar is a substance comparatively harmless to the tree. Used such as it is on restricted surfaces of the bark of a tree—for example, as a circular ring to prevent the access of insects or to cover wounds—it is without action on the growth and does not injure the tree.[1] Tar does not kill the cells which it penetrates, but it preserves them from decomposition so that neighbouring cells may grow and develop normally. The cellular layer which is penetrated by the tar only measures 1-2 millimetres in summer. It is therefore better to apply tar to wounds in winter. It has been found that tar, after remaining seventy days on the tree had not been entrained by the sap, and had not penetrated further than at the time of application. However, Sorauer and Von Tuboeuf remarked that tar must not be abused on fresh wounds or on young trees, for in their opinion it is only old wounds and old trees which stand tar with impunity. Robert

[1] *Translator's Note.*—This is no doubt true as regards old trees, but tar should not be applied to young trees with tender bark.

found, however, that far from injuring the trees, the layer of tar, if it be not too thick, may act as a tonic to the wound and favour cicatrization and thus enable it to cover itself with fresh bark. Boiteau observed on stocks treated with tar rather grave disorders at the beginning of growth: a delay in the latter and chlorotic vine leaves which disappear later on. Sajo has observed that tar, especially wood tar, is injurious to dormant eyes. According to Berlèse and Fleischer, solutions of tar in alkali diluted with water are injurious to the leaves above 5 per cent. Sprayings should never be done during flowering nor before the fruit has formed.

Action on Insects.—Tar is insecticidal by contact, but its action is not intense, and it requires strong doses to kill insects. In strong doses it kills the eggs of butterflies; in solution in caustic alkalies containing 2-4 per cent of tar it kills insects with soft skins, such as lice and caterpillars; from 1-5 per cent it kills *Orthoptera*, *Hymenoptera*, *Lepidoptera*, and *Diptera* (Berlèse). The larvæ of the saw-flies are killed by 5 per cent emulsions (Sonnino).

Use.—Bituminous shale was used by the Greeks to keep off insects. In our days tar is used as it is to destroy the mass of butterfly eggs, and to form around the trunk an impassable barrier, and a trap to apterous insects and their larvæ, which are obliged either to descend the tree to continue their metamorphosis in the soil or to ascend the tree along the trunk after their transformation into a perfect insect. The bouillies obtained by mixing tar, more especially wood tar, with caustic alkali, alkaline carbonates, or with soft soaps, are used in spraying insects with a soft skin. A preparation, sold under the name of "Rubinia," and greatly used, is prepared by boiling 50 parts of wood tar with 50 parts of caustic soda, 30° B. This preparation is soluble in distilled water with a red coloration; it should be diluted with rain water. Tar bouillies are also made containing blue vitriol, naphthalene, and lime. Howard recommends a bouillie of blue vitriol and tar, obtained by stirring energetically $6\frac{1}{2}$ lb. of coal tar with 5 gallons of boiling water into which there is poured when the emulsion is complete, and after removing the blackish froth, a solution of 12 lb. of blue vitriol in 5 gallons of water. Tetard recommends an emulsion with petroleum and carbolic acid made thus: Heat 6 gallons of tar; remove from the fire and add while stirring 3 litres of petroleum and 10 litres of carbolic acid. Balbiani recommends a mixture of coal tar, naphthalene, and lime prepared thus: Dissolve 3 lb. of naphthalene in 2 lb. of coal tar, and pour the mixture into 100 lb. of lime slaked with a little water. After intimately mixing these substances they are gradually thinned by adding 40 gallons of water. Rathay recommends an analogous bouillie containing 4 lb. of coal tar, 12 lb. of naphthalene, and 24 lb. of lime in 6 gallons. "Pitteliene" used in Italy is a mixture of oil and tar.

Use to Destroy Weeds.—One of the most efficient methods to free paths and roads from weeds consists in watering them with an emulsion of equal parts of water and tar. The weeds do not grow again for two years. But it has the disadvantage of being as dear as hoeing and of browning for some time the spots treated. However, it is expeditious and kills earth-worms at the same time.

Use against Fungi.—*Sphærotheca pannosa*, Wallr. (mildew of the rose).—Del Quercia and Baroni found that rose mildew was destroyed by coal-tar bouillies. They advise for this purpose to spray before flowering with a bouillie consisting of 1½ lb. of carbonate of soda and ½ lb. coal tar in 10 gallons of water. The bouillie injures the colour of the roses because it is alkaline. Martini prefers a bouillie consisting of wood tar dissolved in soda lye 1½ lb., blue vitriol 1 lb., quicklime 1 lb., in 10 gallons of water.

Ananas (cane-sugar disease).—This fungus is propagated chiefly by the cuttings. By coating the sections with carbolized tar, Went overcame this disease, preventively, better than by cupric bouillie.

Nectria ditissima, Tul. (canker of the pear-tree and apple-tree).—The cankers of fruit trees, whether caused by the woolly aphis or by the nectria fungus, are overcome and cured when the tree is not too much infested by completely excising them, and covering the wounds by a mixture of wood tar and pulverized wood charcoal, or by a mixture of 1 part of coal tar and 4 parts of pulverized slate, or even by a thin layer of hot tar. The tar prevents contact with the air, kills the germs of cryptogamic disease, and stimulates the growth of the cells of the epidermis so that cicatrization is accelerated and large decorticated surfaces become covered with healthy bark in the course of the year.

Rot of Cuttings.—It has been found that tarring the ends of cuttings prevents their rotting in the soil. This effect is especially noticeable when bouillie bordelaise is combined with the tar by dipping the end to be buried first into the bouillie and then into the tar.

Polyporus igniarius, Fries (false tinder).—To prevent its ravages care must be taken to cover with a layer of tepid tar all the wounds produced on trees by lopping, hail, the sun, woolly aphis. If the hoods of the polyporus show on a branch, this spot must be deeply excised to destroy the greater part of the mycelium, and the whole covered with tar. Hollow trees may be filled with sawdust impregnated with wood tar, and the openings plugged with clay or mastic. That prevents the internal decomposition from pursuing its course, for the fungus must have contact with air for its development.

Slugs.—The ring of coal tar, ⅓-⅔ inch wide, is quite sufficient to prevent snails and slugs from crawling along the trunks of trees and to avoid their ravages (Pastre).

Use on Insects.—*Melolontha vulgaris*, L. (cockchafer).—Razeburg remarked in 1847 that the cockchafer had a great repulsion for tar. He recommended to protect plants against their attacks to bury in the hole, dug for planting, a rag steeped in tar. Weny found that Balbiani's mixture, consisting of tar, naphthalene, and lime, eradicates the white-worm of the vine, and Landisch points out that it suffices to insert, at certain intervals, and at a depth of 10 inches, pegs dipped in tar to protect a crop threatened by the white-worm.

Valgus hemipterus.—A small *sitoma*, the larvæ of which rapidly destroy the props and posts of enclosures, by nibbling the underground part even when tarred. To preserve them, they must be treated thus: The props and posts are coated in the underground portion with a

thick layer of white lead ground in oil. Powdered sandstone is dusted over this layer, and allowed to dry completely. A coat of tar is then given and the props inserted. The wood is thus unattackable, and is preserved for a long time.

Bruchus Pisi (pea weevil).—Fleischer recommends to spread the peas on a sieve and to distribute thereon an emulsion of 1 pint of tar in 2½ gallons of water, and to stir the peas well.

Otiorhynchus populeti (weevil injurious to the vine).—Balbiani's mixture is recommended by Sajo to eradicate this weevil.

Scolytus rugulosus, Koch.—Scolytus very injurious to apple-trees. Bauer recommends to cover with tar the parts of the trunk infested.

Anoxia villosa.—The larvæ of this insect are injurious to the *Magnolia grandiflora*. Camerlings obtains good results by excavating a pit around these trees 32 inches wide by 10 inches deep, and watering these pits with 30 litres (6·6 gallons) of an emulsion of 3 per cent of "Pitteleine". The pits are filled with earth in twenty days.

Galeruca calmariensis (galeruca of the elm).—The most simple way to destroy these larvæ is to seize the moment, at the end of July or beginning of August, when the adult larvæ descend along the trunk to be converted into a grub in the soil. At this time a ring 4-8 inches wide is painted round the trunk near the bottom. The larvæ which descend remain glued to this layer of tar. To destroy those which have let themselves fall, and which are buried in the ground, the soil round the tree is watered with gas liquor from the gas-works. Kunckel recommends a bouillie made by making 5 lb. of tar and 1 lb. of soft soap into a paste, and thinning this preparation with 9·4 gallons of water. This bouillie is used to spread on the leaves.

Haltica Oleracea (the garden altise, the altise of cruciferous plants). —These altises entirely nibble the seedling turnips, cabbages, and rapes, and other cruciferous seedlings, especially during hot and dry periods when the fields are despoiled of their crops. At that time a very efficacious method consists in spreading dry wood sawdust steeped in tar. The earth fleas are driven off by the smell of the tar; 2 lb. of tar per 100 lb. of sawdust are used (Bouvier).

Locusta (locusts).—To destroy these on the large scale a 5-10 per cent solution of rubinia is used (Petrobello).

Pieris Brassicæ (white cabbage butterfly).—The grubs are killed by a 2 per cent solution of rubinia (Berlèse).

Ocneria dispar, L. (bombyx dispar, gipsy moth, zig-zag); *Cnethocampa processionea* (processionary bombyx of the oak).—The eggs of these bombyces are killed by tar; a layer of tar is spread on the agglomerations of the eggs. Debray advises to use a mixture of 4 gallons of tar and 1 gallon of petroleum. Jacobi found the tar more effective than the petroleum. To kill the caterpillars in their nests Sonnino sprays with a 5 per cent solution. Pissot recommends to drench the nests with a mixture of 10 parts of tar and 100 parts of water. Berlèse finds it better to use an emulsion of 2 per cent of "Pitteleine".

Bombyx pini (the pine-tree lappet moth).—Ratzeburg advises, so as to glue them on their passage along the trunk, to draw a ring on the bark at the right times, 52 inches from the ground and 6½-9½

inches in diameter. The scales of bark are removed from this spot, and it is then coated with tar. A little grease is often added, or birdlime made by heating linseed oil. The caterpillars which touch the tar die in a few days.

Cheimatobia brumata, L. (the winter moth).— De la Blanchère finds the best way to overcome this moth is to prevent the female from climbing along the trunk of the trees to lay its eggs. With this end in view the trunk is scraped a little above the surface of the soil, and this ring is coated with tar or with a mixture of equal parts of tar and fish oil. To protect young trees sensitive to tar a band of paper or cardboard is fixed around the trunk and coated with this sticky substance. The paper must fit well round the trunk. These rings should be made from the end of September to the end of December, and renewed from time to time if necessary—every three days if made with pure tar; at greater intervals if they consist of different sticky substances. Unfortunately, these last preparations are less harmless than tar to the health of the tree. Leroux advises to shake the tree by sharp blows, which causes the females to fall. These to reascend the tree encounter the obstacle of a fresh layer of tar. The females hatched prematurely are thus reached. C. de Labonfon advises from 20 October to 20 November to surround the trunks of apple-trees and pear-trees, about 3 feet from the ground, with a piece of course stuff held by a hook and steeped in coal tar. The eggs deposited below the ring by the females, pressed to lay, are destroyed by scraping or by liming.

Grapholitha Woeberiana (tinea of stone fruit). To overcome this tinea, the trunk is scraped and a slight layer of tar applied. If the operation be done in season it will prevent the female from laying its eggs on the trunk.

Hyponomeuta malinella (small ermine moth of apple-tree).—To destroy these caterpillars Taschenberg advises a 5 per cent emulsion.

Conchylis ambignella, Hubn. (cochylis of the vine).—Opinions are much divided as to the action of "rubinia" on caterpillars of the cochylis. Fracasso, Legrenzi, Farini, and Silva found 4 per cent doses of "rubinia" inactive, whilst Berlèse, Martini, and Peglion find it energetic at the same strength. The latter does not injure the vine. Peglion recommends to use these solutions before flowering or after the grape is formed, so as to prevent the injurious action of the product during flowering. Mixtures of sulphur bouillie bordelaise and "rubinia" are used in Italy to combat simultaneously cryptogamic diseases and the cochylis. These preparations destroy the eggs. Martini found that eggs of the cochylis laid on paper steeped in "rubinia" never hatched. He advises to use the following mixture: "Rubinia" 1½ lb., blue vitriol 1 lb., quicklime 1 lb., in 10 gallons of water. Berlèse and Leonardi recommend spraying the buds as soon as they shoot out with a bouillie consisting of 5 lb. of rubinia, 5 lb. of blue vitriol, 5 lb. of lime, in 10 gallons of water. After flowering the sprayings are continued and repeated to the beginning of July with a bouillie of rubinia 1½ lb., blue vitriol 1 lb., lime 1 lb., in 10 gallons of water. A diminution of 62-63 per cent of cochylis is obtained in that way. Battaglini recom-

mends preventive treatment either with 1 per cent rubinia or with a mixture of 2 per cent "rubinia" with sulphur. Spraying should be begun on 28 April. The number of eggs diminishes by the first treatment. The eggs disappear after the second, which should take place on 15 May; the third treatment is given on 27 June, and the fourth on 4 July.

Tortrix vitana (pyralis of the vine).—G. Basile proposes to coat the vine after pruning with a mixture of 6 lb. of tar in 10 gallons of purin. Scalding, however, gives better results.

Hylotoma Rosæ (rose saw-fly).—To destroy, spray with 2 per cent "rubinia," (p. 338) in fine weather, preferably at noon (Berlèse and Girardi).

Eurydema ornatum.—To destroy, water the cabbage leaves with tar-charged water.

Schizoneura lanigera, Hausm (woolly aphis).—To destroy this aphis Del Quercio, after pruning the trees and cleaning the nodosities, coats the wounds with an emulsion of tar 3 lb., soft soap 5 lb., water 9·6 gallons. In summer an emulsion is used of carbonate of soda 5 lb., wood tar 5 lb., water 10 gallons. Muhlberg found that rectified Russian tar, and so to speak colourless, is an excellent medium to induce the cicatrization of wounds formed by the woolly aphis. A tree treated by an emulsion of soft soap and amyl alcohol, Nessler's formula, and the wounds of which have been afterwards tarred, may be regarded as cured. Tiele ranks tar amongst the insecticides whose action is undeniable and decisive.

Green Lice.—Berlèse used with success a solution of "Rubinia," 1-5 per cent, against green lice; according to Fleischer, it is only with 5 per cent that a deadly action makes itself felt, but at this strength it is dangerous to the plant.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—Mouillefert showed that tar vapours have little insecticide action on the phylloxera. Used in holes dug round a phylloxera-infected stock, tar had no action. However, by increasing the dose and getting nearer the roots so that the tar could act directly and completely drench the soil, it was found to have an appreciable though incomplete effect. Tar may be used to destroy the winter egg deposited by this louse on the aerial parts of the plant. Balbiani recommends for this purpose his mixture of tar, naphthalene, and lime, used as a coating.

Coccides (cochineal, kermes).—Tar is used sometimes such as it is to destroy cochineals. A thin layer of tar bouillie is spread with a brush on all the trunks. Sajo found that it was tar, especially rich in anthracene, which had a specific action on kermes, chiefly the *Mytilaspis pomorum*, Bouché. This tar is, however, more injurious to the apple than ordinary coal tar. Del Quercio recommends a soapy bouillie consisting of tar 10 lb., soft soap 2 lb., water 8·8 gallons. It is used in winter spraying. After flowering, and during summer, an emulsion must be used of soft soap 30 lb., tar 10 lb., petroleum 2 gallons, in 100 gallons of water, and prepared by mixing 20 lb. of soft soap and 10 lb. of tar on the one hand, and emulsifying, on the other hand, 2 gallons of petroleum and 10 lb. of soft soap in 97 gallons of water, and in mixing the two solutions. This latter treatment is re-

commended against *Mytilaspis fulva, Aspidiotus Limonis, Lecanium Hesperidum, Lecanium Citri, Dactylopius Citri.* "Rubinia" is much used to combat cochineals. Berlèse recommends 5 per cent, especially against *Dactylopius Vitis* (cochineal of the vine), and Marchal against kermes of the orange-tree. Girardi recommends the use of a 1 per cent solution at the moment when the young larvæ quit the protective shell of their mother and circulate round the tree in search of a place on which to fix themselves. The tar and oil emulsions known as "Pitteleine" are recommended by Berlèse of 2 per cent strength against *Lecanium*, and by Marchal against kermes of the orange-tree. Del Quercio recommends for the treatment of winter fruit trees, an emulsion of tar 1 gallon, carbonate of soda 5 lb., and water 9 gallons. The carbonate of soda is dissolved in the water and the tar added afterwards whilst stirring.

A 10 per cent solution of tar kills anthonomes in five minutes. It must be used for this purpose in October and November. The females of *Mytilaspis pomorum* and *Diaspis ostreaformis* are killed at the same time as their eggs. It would appear also that the branches which have been repeatedly sprayed therewith are no longer sought after by these cochineals. A 4 per cent emulsion destroys mosses and lichens. To destroy cochineals, Mottareale indicates on the one hand, an emulsion consisting of tar oil 10 lb., soap 10 lb., water 100 gallons, and on the other hand, alcoholic solutions consisting of tar oil 5 lb., alcohol 5 lb., water 99 gallons.

Tetranychus telarius (red spider).—Rathay recommends to bark the stock in autumn and to coat it with his mixture of tar, naphthalene, and lime, for in the end of October these acari take refuge under the bark of the stem. The barks should be burned. Berlèse recommends spraying the plant in full growth with 2 per cent solutions of rubinia.

Rabbits and Mice.—Brecher recommends as an infallible method to prevent rabbits and mice from attacking the bark of poplars, to coat the trunk up to 12 inches above the soil with a thin layer of wood tar. Trantwein agrees.

Birds.—To protect seed-corn against the voracity of birds it suffices, according to Howard, to moisten it with a bouillie of the following composition: Blue vitriol 12 lb., tar 6½ lb., in 10 gallons of water. The grain is moistened with this bouillie, then dusted with slaked lime to dry it. The following bouillie, recommended by Tetard, is used for the same purpose: Heat 6 gallons of tar, take off the fire, and mix with it whilst stirring 3 gallons of petroleum and 10 gallons of carbolic acid. Crows have a decided antipathy to this odour. One gallon suffices for 1000 lb. of seed.

127. Naphthalene, $C_{10}H_8$.—**Preparation.**—By collecting in the fractional distillation of coal tar the heavy oils which pass between 180° and 260° C. These are let stand for some time in a cold place: crystals of naphthalene are deposited which are turbined to separate the oils containing the phenols and the foreign hydrocarbides. These naphthalene crystals are passed to the hydraulic press, and afterwards washed with caustic soda and sulphuric acid, then with hot water. The rectification is finished by distillation in cast-iron retorts; the

naphthalene distils between 210° and 220° C. It is collected in conical wooden vessels slightly moist, in which it solidifies in a few hours. By reversing the moulds, cakes of pure naphthalene are obtained. For agricultural purposes crude naphthalene may be used. It is rarely used alone. It is mixed with such substances as plaster, lime, wood ashes, or sawdust, is drenched with fused or dissolved naphthalene. A great use is made of a mixture of tar, naphthalene, and lime, brought out by Balbiani, and named after the inventor, Balbiani's ointment. It is prepared thus: Slake 120 lb. fat quicklime in lumps by pouring on to it a small quantity of water from a watering-can. The heat disengaged by the hydration of the lime is used to melt 20 lb. of coal tar, and 60 lb. of crude naphthalene, which is run into the lime whilst it is still steaming. The whole is kneaded by an iron stirrer. Whilst continuing to stir the mixture a little water is added so as to sustain the heat of the lime and to keep the mixture pasty. When the lime is slaked no more water is added, the ointment is finished when the paste is homogeneous. Solutions of naphthalene in benzene and alcohol are also used at the rate of 1 part of naphthalene for 8 parts of solvent (say 1 lb. to a gallon).

Properties.—Pure naphthalene forms white scales with a strong odour and a bitter aromatic taste. Insoluble in cold water, very slightly soluble in boiling water, naphthalene is soluble in alcohol and benzene.

Action on Plants.—Naphthalene does not appear to injure plants; benzene solutions, according to Debray, have no injurious action on the leaves. Mohr's opinion is, however, that this solution injures the parenchyma of plants. The germinative capacity of seed which has been even in prolonged contact with naphthalene is not diminished.

TABLE LXXIII.—*Showing Action of Naphthalene on Germinative Capacity of Cotton Seed.*

	Percentage of Seed Germinated.	
	Seed Covered with Cotton.	*Seed without Cotton.*
Untreated	86	91
Treated with naphthalene, 8 days . .	87	91
,, ,, 14 ,,	91	90
,, ,, 3 ,,	87	88

Action on Insects.—The experiments of Dufour have shown that naphthalene, so to speak, has no action on caterpillars; however, its smell is so disagreeable to insects in general that this substance drives them off and eradicates them at the time of laying their eggs. The vapours of naphthalene stupefy insects, but they recover in the fresh air.

Use.—Naphthalene enters into the composition of many anticrypto-

gamic preparations, such as Crouzel's anticryptogamic, Schlœsing's nicotined precipitated sulphur, to which they impart the special properties of removing insects whilst overcoming cryptogamic diseases.

Silpha opaca, L. (beet carrion beetle).—Dust the young plants with naphthalene to protect them against that insect.

Melolontha vulgaris (cockchafer).—To get rid of the white-worm, De la Blanchère advises to water the soil with water which has been kept over naphthalene. Marsaux advises to bury per acre with the plough 2 cwt. of naphthalene mixed with an equal weight of sand. Finot advises in the culture of strawberries to spread three handfuls of naphthalene per 10 square metres or to dust the dung with it before ploughing it in. Audoin recommends the preventive use of naphthalene to drive off the female cockchafers in quest of a light soil in which to lay their eggs, to sow per acre in April of the cockchafer years 352 lb. of naphthalene per acre, mixed with three times its weight of sand. This method drives off at the same time the females of *Vesperus Xatarti* in vineyards.

Agriotes lineatus (striped wire-worm).—When the soil is infested with the wire-worm larvæ of this insect they are got rid off, according to Targioni-Tozzetti, by naphthalene buried in the soil. The action of naphthalene does not last long, and the operation must be frequently renewed.

Helops lanipes, injurious to the same extent as *Opatrum sabulosum*. Chapot records excellent results, obtained in driving off these insects, by the use of 15-20 grammes (say $\frac{1}{2}$-$\frac{3}{4}$ oz.) per stock, mixed with the soil around the latter.

Colaspidemum atrum, Ol. (Negril).—Crouzel recommends to spread by hand, after the last colds of winter and before the lucerne shoots up, a finely pulverized mixture of 20 parts of naphthalene and 80 parts of plaster or very dry ashes. A fresh application is given immediately after the first crop is cut so that only the roots of the plant and the soil are impregnated. The smell and taste of naphthalene are thus not imparted to the fodder.

Otiorhynchus hirticornis.—Taschenberg reports that coating the vine with Balbiani's ointment prevented it being visited by this insect.

Atomaria linearis, Steph.—To drive off these destroyers of young beets Mohr advises to spread on the soil, by means of a bellows, a mixture of 10-15 per cent naphthalene and 85-90 per cent of lime in powder passed through a sieve.

Calandria granaria (wheat weevil).—To remove weevils from wheat seed it suffices to mix it with a little naphthalene.

Crioceris asparagi, L. (asparagus beetle).—A mixture of 15 per cent naphthalene and 85 per cent of lime in powder kills the larvæ and keeps off laying females.

Halticineæ (altises, earth lice, plant lice).—Thiel and Reichenbach have shown that naphthalene does not kill altises, but stupefies them and drives them away from a crop ; moreover, it is much used for that purpose. Mohr advises a mixture of 15 parts of naphthalene and 85 parts of lime spread on the fields when the young plants shoot up. The effect is felt in twelve hours, but it does not last long,

and the altises return if the treatment be not repeated up to the time the plant need no longer fear their attack. A mixture of naphthalene, sand, or dry earth may be spread on seedlings with the same success. Naphthalenized sawdust is much used to destroy altises of kitchen gardens. It is made by dissolving 10 lb. of naphthalene in ½ gallon of coal tar, then pouring the solution obtained on 20 lb. of quicklime previously slaked with water. After thinning the whole down in 15 gallons of water the sawdust is drenched therewith.

Gryllotalpa vulgaris (mole cricket).—To drive it off it suffices to bury a little naphthalene in the ground as it is being tilled.

Ants.—Sow a mixture of naphthalene and lime where necessary (Mohr).

Anthomyia antiqua, Meig. (onion fly).—Sawdust (naphthalenized) or naphthalene buried in the soil when the onions are planted drives off the fly from these plants and prevents them from laying their eggs.

Tinea granella, L. (grain mite) ; *Ephestia Kuehniella* (flour mite).—The grubs of these tinea cause considerable havoc; the first in granaries, and the second in flour mills. They may be removed by spreading naphthalene in the stores. Seed-corn may be mixed with naphthalene without prejudice to its germinative capacity, but its action is less efficient than that of carbon disulphide, and naphthalene cannot be put in contact with flour to be used as food.

Carpocapsa pomonella (codlin moth).—Taschenberg recommends to hook on to the tree rags steeped in naphthalene to prevent the females from laying their eggs on the young apples.

Conchylis ambignella, Hubn. (cochylis of the vine).—Pradel advises simultaneous treatment of oidium and cochylis by a mixture of sulphur 9 lb. and naphthalene 1 lb. Dufour has, however, shown that the vapours and the soapy emulsions of naphthalene did not have much action on the caterpillars of the cochylis. This treatment, which has, however, given satisfactory results on the large scale, would only drive away laying females and cause the grown caterpillars to fall to the ground. Dr. Paul Cazeneuve found that all the methods of treatment against this insect, pyrethra, soapy emulsions of turps, and petroleum, yield inferior results to the sulphur and naphthalene mixture. Spraying on the grapes is done by a mechanical sulphurator as soon as flowering commences. Some caterpillars already on the grapes quit them precipitately after this naphthalenized sulphurating, the odour of which is repugnant to them. The last treatment is given between 1 and 10 August to combat the second generation of the cochylis. The taste of naphthalene in the wine is not to be feared, because there is no adherence ; it is washed off by the rain. When oidium is not to be combated sulphur may be replaced by talc or plaster. To make an intimate mixture of talc or plaster it must be passed through a crushing mill (edge runners or flat stones ?).

Aphides.—Taschenberg advises to project a mixture of 1 part of naphthalene with 2 parts of ashes or plaster. The moment is chosen when the leaves are moist with dew, or this treatment is preceded by spraying with water.

Schizoneura lanigera, Hausm. (woolly aphis).—Solutions of 1 part

of naphthalene in 8 parts of benzene or alcohol (say 1 lb. to gallon) are used in summer to destroy the woolly aphis. The nodosities are coated with the brush. Better results are got with a solution of 5 lb. of naphthalene in 10 gallons of burning oil. The asphyxiating action of this oil makes itself felt at the same time as the insecticidal action of naphthalene. Guozdenovic destroys the woolly aphis by a mixture of tobacco extract 15 lb., soft soap 10 lb., naphthalene $\frac{1}{2}$ lb., in 100 gallons of water, to be used by spraying on the colonies.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—Mouillefert found that naphthalene had no action on this louse. Trials made on the large scale by placing naphthalene in proximity to the contaminated roots gave negative results; however, a German patent advises to destroy this louse to drench peat with naphthalene carbon disulphide or tar, and to bury it near the infected stocks. If it is asserted that naphthalene cannot destroy the perfect insect on the roots, it has been shown that Balbiani's ointment (mixture of naphthalene tar and lime) destroys the winter egg, laid on the aerial part of the plant. The treatment is recommended, both to obtain immunity from the phylloxera in non-infected districts, and as an aid to the underground treatment of insects. Henneguy, who is a zealous advocate of this process, declares that the coating applied preventively on non-infected vines suffices to preserve them from phylloxeric invasion. Coating is done by a painter's brush or by a whitewash brush. The whole wood of the stem is coated all over the surface of the stock, taking no notice of buds and cut sections. The work is done preferably after the pruning of the vine during the whole winter. The best time, however, is the month of February, when the egg's time is up and the louse is hatched. As there are always some winter eggs which escape this treatment, the process is not efficient and useful, unless used concurrently with treatment underground by carbon disulphide.

Coccides (cochineals, kermes).—To destroy the cochineal of the vine, scraping and barking play a great part. They are crowned with success if this mechanical treatment be followed by coating with Balbiani's ointment, the insecticide action of which has been shown by Couanon. It is especially energetic at the time the larvæ are hatched. Guozdenovic obtained at the Experimental Station of Spalato in Austria good results against *coccides* by spraying with an emulsion consisting of tobacco extract 5 lb., soft soap $2\frac{1}{2}$ lb., finely pulverized naphthalene $\frac{1}{10}$ lb., in 50 gallons of water.

Phytoptus Piri (gall mite of the pear-tree).—Erinose of the pear-tree may be overcome after decortication by coating the trunk and the branches with Balbiani's mixture.

Tetranychus telarius (red spider).—Viala and Valery Mayet have recommended the decortication of the stocks followed by coating with Balbiani's mixture.

CHAPTER XXII.

CARBON COMPOUNDS (*continued*)—TERPENES—OLEO RESINS—GALIPOT—TURPENTINE—ROSIN—ROSIN SOAPS—ROSIN EMULSIONS—METALLIC ROSINATES—COPPER ROSINATE—CAMPHOR.

Terpenes.—Terpenes are met with in many essences and balsams of which they form the liquid part. The different pines and spruces, the junipers and plants of the family of terebinthaceæ, segregate them in the vacuoles of their liber.

128. Turpentine.—Turpentine is the resinous sap[1] (*suc resineux*) which flows from incisions made on trees of the conifer family and terebinth family. The name of galipot is given to the partially solidified resin which forms long tangles along the bark. These resinous saps [oleo resins is the better term] are very complex mixtures. The crude matter distilled either directly or in a current of steam furnishes about 15 per cent spirits of turpentine ; the residue forms rosin of a very complex nature. [The chemical technology of rosin is fully described in McIntosh's "Varnishes," Vol. III., Scott, Greenwood & Son, and the maker of insecticide emulsions should consult that section of the book, which deals with rosin and turps, with profit.—(Tr.).]

In the air terebinthene (pinene), which is the carbide of hydrogen (terpene) of spirits of turpentine, becomes viscous and resinifies; first the oxygen combines in an unstable way with the terebinthene (pinene), which under these conditions acquires oxidizing properties similar to ozone, and thus antiseptic and disinfectant. Turpentine and rosin are insoluble in water, but they contain saponifiable principles which have led to the manufacture of resinous soaps greatly employed in aboriculture.

Action on Plants.—The different principles of turpentine are injurious to plants. Spirits of turpentine (*turps*) 2-5 fluid oz. per $6\frac{1}{2}$ gallons bulk of soil is already very poisonous to plants, especially the vine. The aerial organs touched by spirits of turpentine emulsions are damaged, and the spraying of the trunk of vines causes burns. Turps appears more dangerous to the plant than petroleum ; resins are more poisonous than tar.

Action on Insects.—The products contained in turpentine have a very pronounced destructive action on insects. Turpentine [? turps or oleo resin] spread on the agglomeration of eggs of *Ocneria dispar* (gipsy moth) acts as efficiently as tar (Robbes, Sajo).

Use.—*Spirits of Turpentine* (turps).—Turps is never used alone

[1] Turpentine is not the sap or juice of the tree. It is an oleo-resinous exudation and bears a somewhat similar relation to true sap as sweat does to the blood. Spirits of turpentine is often but most erroneously designated as "turpentine," a term to which it is no more entitled than starch is to being termed wheat or potatoes.—Tr.

if it be not to destroy the agglomeration of eggs of certain butterflies (*Ocneria dispar*, gipsy moth). It is used in emulsion with water or soap solution, most often with carbon disulphide, milk, or tar.

Conchylis ambignella, Hubn. (cochylis of the vine).—In Dufour's insecticide turps replaces pyrethra powder, which is difficult to procure fresh. Dufour dissolves 30 lb. of soft soap in hot water, adds cold water to make 100 gallons, and incorporates 2 gallons of turps in this soap solution, then emulsifies the whole with a spraying machine. It is necessary to use 13·2-35·2 gallons per acre.

Schizoneura lanigera, Hausm. (woolly aphis).—A mixture containing turpentine [oleo resin] has been elaborated by Goldi, and is in common use against the woolly aphis. This mixture has the following composition: Fresh milk 60 per cent, turpentine [oleo resin] dissolved in turps 20 per cent, carbon disulphide 20 per cent. In a stoppered bottle this mixture keeps a long time. The aerial colonies are coated with a brush. To disinfect roots, the following mixture must be used: Milk 60 per cent, turpentine 30 per cent, carbon disulphide 10 per cent.

Grafting Wax.—To cover the wounds after destroying the insect grafting wax is recommended (rule in force in the Canton of Argovy in Switzerland), consisting of Venice turpentine 65 per cent, turps 20 per cent, ochre 20 per cent, or 75 per cent of turps and 25 per cent of tar.

Phylloxera vastatrix, Pl. (phylloxera of the vine).—Mouillefert examined the action of turps on the phylloxera, and found that it was very pronounced. If it perfectly destroyed the phylloxera, on vine roots planted in pots, it was not the same on the large scale. By treating the stocks with 400 cubic centimetres of turps emulsified with water, and sprinkling afterwards with water, and bringing the earth back around the stripped stocks, this product has proved powerless to destroy the insect in the lower reaches of the soil. The coating of the trunk and the roots of the phylloxera-infected vine with 50-100 cubic centimetres of turps (Sans process, 1872) has given no favourable result.

Cochineal.—Hoffmann recommends to render soapy emulsions more energetic against cochineals to add carbon disulphide or turpentine (? turps). An emulsion of 2 per cent soft soap and 2-3 per cent of turpentine (? turps) gives excellent results.

Moles.—To drive away moles, it suffices to pour water in their burrows, and to lower a cup containing a mixture of petroleum and turpentine.

129. Pine and Spruce Resin [*? Rosin*].—These are used in: (1) Soap emulsions; (2) the preparation of coatings and bird-limes; (3) in cupric bouillies to render them more adherent. The resins [? rosins] are used as such or saponified.

(1) **Saponified Resins** [rosin soaps].—**Preparation.**—Several methods are used in America[1]:—

[1] These formulæ are given in the original French edition of this treatise in metric weights and measures. But the author like every other author who quotes American formulæ seems to forget that an American gallon is only five-sixths of an Imperial gallon. In America the pound is not the tenth part of a gallon but three-twenty-fifths. Had the author made allowance for the American gallon it would have been impossible for him to have got the French quantities in such round numbers to the litre.

1. Dissolve 1 lb. of 98 per cent caustic potash in 4 gallons of water; add thereto 9 lb. of rosin, heat until complete solution is effected and make up to 10 gallons by adding the necessary water. The brown liquid so obtained is translucid (Koebele).

2. Boil together for one hour 7 lb. of 70 per cent caustic potash, 25 lb. of rosin, and 3 lb. of fish oil, with 10 gallons of water. As soon as the mass rises and becomes frothy, stop the boiling and make up with water to 100 gallons (Coquillet). This bouillie is the classic rosin bouillie of America. The following formulæ are now in use. Formula A: caustic potash, 70 per cent, 6 lb., rosin 25 lb., fish oil 3 lb., water 10 gallons. Formula B: caustic potash, 70 per cent, 10 lb., rosin 35 lb., fish oil, 5 lb., water 10 gallons. Formula A is used in summer, thinned down according to the sensitiveness of the tree, with seven to nine times its weight of water. Formula B is only used in winter when the sap is dormant.

3. 16½ lb. rosin, 2½ lb. caustic potash, 98 per cent, and 2½ lb. of fish oil are heated together and then dissolved in 10 gallons of water.

4. 16 lb. rosin, 4 lb. 98 per cent caustic potash, 2½ lb. of fish oil are melted together, and boiled in 10 gallons of water, cooled, and 4 gallons of water added. Before use 1 part is diluted with 9 parts of water (Swingle).

5. Dissolve 8-10 lb. of commercial rosin soap in 10 gallons of water.

Action on Plants.—Soap solutions of 0·8-1·0 per cent strength do not injure the leaves. A bouillie six times stronger than Formula A used warm in December and January, resulted in the total absence of flowers in the spring (Marlatt).

Action on Insects.—Rosin emulsion acts very energetically on insects owing to its causticity; it acts by contact and it forms besides on the insect which it has drenched an impermeable coating which causes asphyxia.

Use.—Rosin bouillies are much used in America against caterpillars, and especially against cochineals; they replace petroleum emulsions. They give very good results in countries where the prolonged absence of rain assures the efficiency of the treatment for a long period, and where the multiplication of the cochineal, owing to the heat, goes on almost without interruption the whole year round. Petroleum emulsions are preferable in districts where rain is frequent. When a resinous bouillie is used on a tree invaded by cochineal the bark of the tree must, as far as possible, be entirely drenched. In temperate countries two or three applications must be made at eight days' interval, and preferably at the time when the mobile larvæ circulate in quest of a spot on which to fix themselves. The treatments do good on deciduous trees. When the tree is much attacked it must be severely pruned before spraying. To give all its efficiency to the winter treatment, a dose six times stronger must be used than in summer, when, on the contrary, the bouillie made from No. 2 formula is thinned down with nine times its volume of water.

By this process, and with the emulsion from formula No. 4, Swingle and Webber destroy the following caterpillars and lice: *Ceroplastes*

fluoridensis, *Dactylopius Citri*, *Aphis gossypii*, Glover; *Lecanium Oleæ*, *Icerya purchasi*, *Aleyrodes Citri*. Gossard used with great success an emulsion of ground rosin 16 lb., caustic soda, 98 per cent, 3·4 lb., fish oil $2\frac{1}{2}$ gallons, water 100 gallons, applied in winter when the cochineals are in the larva state. Marlatt recommends to destroy *Aspidiotus Aurantii*, Mask, *Aspidiotus citrinus*, Coq., the summer bouillie formula No. 2 A. A bouillie four times stronger kills 85 per cent of *Aspidiotus perniciosus*, Comst. (San José louse), *Phorodon Humuli* (hop aphis). It does not stand spraying with a solution of rosin soap, formula 5.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—Koebele's trials were a failure. Emulsions do not penetrate the soil sufficiently and do not reach all the phylloxeras. Only the insects touched die.

Aspidiotus uvæ, Comst., on vine.—Galloway's bouillie No. 3 is recommended for its destruction.

Tetranychus telarius (red spider).—Bouillie No. 3, diluted with 3-4 parts of water, is recommended to destroy it.

(2) **Compositions and Bird-limes** (*Enduits et glus*).—Formulæ for preparing coating compositions: 1. 200 oz. spruce resin (*resine de sapin*, ? Burgundy pitch) are heated over a gentle fire until fused, then 5 oz. of linseed oil and 10 oz. of honey added; when the mixture is homogeneous it is removed from the fire, cooled, and 28 oz. (wt.) of 90 per cent alcohol added. This coating should be kept out of contact with air; it is used cold (Lucas).

2. 500 oz. of spruce resin are fused and dissolved in 75 oz. (wt.) of 90 per cent alcohol; 4 oz. of gum-arabic dissolved in very little water are added, and 20 oz. of carbonate of soda.

3. Melt together equal parts of rosin, wax, and turpentine. This composition is applied hot (Sorauer).

Bird-limes are made as follows: 1. Heat together and reduce to two-thirds of the original volume $2\frac{1}{2}$ lb. of colza oil and $\frac{1}{2}$ lb. lard, then add whilst stirring $\frac{1}{2}$ lb. of turpentine and $\frac{1}{2}$ lb. of rosin. The consistency should be syrupy; if it be too fluid the heating is to be continued, if it be too thick more oil is added. This bird-lime remains sticky for three months.

2. Heat together 5 oz. of rosin, 4 oz. of stearine, and 4 oz. of lard.

3. Heat together 5 oz. of rosin, 2 oz. of lard, and then add 1 oz. of turpentine, and then 2 oz. of stearine; boil to a suitable consistency.

4. Heat with care 7 lb. of wood tar with 5 lb. of rosin; when the whole is fused add 5 lb. of soft soap, then 3 lb. of cod oil; remove from the fire and stir till cold.

Use.—Cold coating compositions (*Enduits*) are used to protect young buds from insects. Sorauer advises to cover them with a thin layer which, whilst it drives off insects, does not prevent the normal evolution of the bud. It is an effective protection against *Tortricides*, *Tineides*, as well as against weevils: *Otiorhynchus*, *Magdalis*, *Peritelus*, and others. To prepare a very thin coating Henschel recommends to dilute it previously with alcohol. Cold or hot coatings are used with success to cover the wounds of trees.

Bird-limes have found a current use in replacing tar rings. Rings

of bird-lime are applied about 5 feet above the surface of the ground. It may be applied directly on the bark of old trees. With young trees the treatment is risky. Hartig and Sorauer found that thin-barked young trees are sensitive to bird-lime, and the bark, being penetrated by it, the tree dies in a few years. When young trees are to be protected, the trunk of the tree is encircled by a band of paper 11 centimetres (say 4½ inches) wide, which is coated with bird-lime. It is well to keep the ring on all the year round and to renew it whenever it loses its stickiness, say about every three months. The ring of bird-lime is much more effective than the classical tar ring; like the latter, it retains all the apterous insects which ascend from the soil on to the tree by the trunk, or which descend by the same road to metamorphose in the soil. Thus the *Cheimatobia brumata*, L., and the *Hibernia defoliaria*, L., apterous phalena, the larva of *Eriocampa adumbrata*, and the *Psylla* of the pear-tree are easily destroyed in that way.

Schizoneura lanigera, Hausm. (woolly aphis).—To combat this aphis Clarac recommends to coat the spots invaded by colonies, that is to say, all the bark, by a mixture made by heating 2 lb. of tallow, 3 lb. of rosin. 5 lb. of poppy or colza oil.

(3) **Bouillies.**—Rosin is added to increase the adherence of a copper bouillie. The following formulæ may serve as a guide: 1. Blue vitriol 12 lb., lime 15 lb., rosin 6 lb., soap 7 lb., water 100 gallons. 2. Blue vitriol 12 lb., rosin 15 lb., soap 6 lb., water 100 gallons.

130. Camphor, $C_{10}H_{16}O$.—**Natural Occurrence.**—Camphor is extracted in China and Japan from old camphor trees, *Laurus camphora*, by sublimation—heating the roots and branches. It is refined in Europe by fresh sublimation.

Properties.—Camphor is a white, semi-transparent, crystalline substance. It has a characteristic, fresh, aromatic odour. Its density is from 0·992 at 10° C. It melts at 173° C. and boils at 204° C., but it volatilizes perceptibly at the ordinary temperature. Water dissolves 1 part in 1300 at 20° C. Alcohol and oils dissolve it freely. Camphor is a poison of the protoplasma; even in dilute solution its antiseptic power is known. It has been used from the most remote times. It has a poisonous action on the lower animals, chiefly the arthropodes, which are killed by the vapours emitted by camphor at the ordinary temperature.

Use.—*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—From 2-3 grammes of camphor run into a hole dug by a gimlet, as far as the pith of the stock, and then corked, had a certain action on the phylloxeras of the roots, but destruction was incomplete (legal process, 1872). Watering the ground round the stem with a bouillie of 10 lb. of camphor, 25 lb. of ammonia, and 25 lb. of lime, had no good effect.

Mice.—To protect seed-corn from mice it suffices to mix it with a little camphor before sowing it. The smell drives off the rodents.

CHAPTER XXIII.

CARBON COMPOUNDS (*continued*)—NITROBENZENE—CARBOLIC ACID—PICRIC ACID—CRESOL—SAPOCARBOL—CREOSOTE—CREOLINES—LYSOL—POTASSIUM DINITRO-CRESYLATE—THYMOL—β-NAPHTHOL METHYL VIOLET.

131. Nitrobenzene, $C_6H_5NO_2$.—**Preparation.**—By pouring very slowly, whilst stirring, 1 part of benzene into a cold mixture of 2 parts of nitric acid of 40° B., and 2 parts of sulphuric acid of 66° B. When nitrobenzene is formed water is added till it separates. It is decanted and washed several times with pure water, then with water to which a little carbonate of soda has been added.

Properties.—Nitrobenzene is a yellowish liquid boiling at 213° C., of a sweet taste, having the smell of bitter almonds. It is insoluble in water, but soluble in alcohol, benzene, and oils. It is poisonous (Olivier and Bergeron); the poisonous symptoms are the same as those produced by aniline cyanose. The fatal dose for a man is 8-9 drops (Letheby), 20 drops (Bardt).

Action on Plants.—The experiments of Papasogli, Targioni-Tozzetti, and Del Quercio, have shown that soapy emulsions containing 0·5-0·75 per cent of nitrobenzene, and soapy and alcoholic emulsions containing 0·25-0·5 per cent, are not injurious to plants. Zechini and Silva found, on the other hand, that a 2 per cent nitrobenzene emulsion is very injurious to the vine.

Action on Insects.—Nitrobenzene poisons insects. From the author's experiments the nitro group would appear to increase appreciably, and in a general manner, the toxicity of aromatic compounds. Papasogli found that a milligram of nitrobenzene, evaporated under a cloche, killed all the eggs of the fly and of *Bombyx Mori*. According to the author's experiments nitrobenzene prevents the hatching of chrysalides.

Use.—Papasogli recommends to destroy soft-skinned insects and plant lice by an emulsion prepared thus: Dissolve 50 lb. of nitrobenzene in 150 lb. of amyl alcohol, and add thereto 100 lb. of soft soap. This insecticide is thinned down before use, and according to the sensitiveness of the plant, with 10-20 parts of water, so as to get an emulsion containing nitrobenzene 0·84-1·7 per cent, soft soap 1·7-3·4 per cent, amyl alcohol 2·6-5·1 per cent.

Agrotis Segetum (grey-worm).—Papasogli recommends to water beets with an emulsion of 5 lb. of nitrobenzene, 5 lb. of sulphuric acid, in 9 gallons of water, to kill the grey-worm, the caterpillar of this noctua.

Conchylis ambignella, Hubn. (cochylis of the vine).—The caterpillar

is killed by an emulsion containing 2 per cent of nitrobenzene; but of that strength the insecticide is prejudicial to the vines (Zechina and Silva). Dufour also found that the maximum strength of a soap emulsion of nitrobenzene should be 2 per cent nitrobenzene and 3 per cent of soft soap.

Schizoneura lanigera, Hausm. (woolly aphis).—Nitrobenzene enters into the composition of an insecticide made in Switzerland, "Knadolin," invented by Kraft and recognized by the Federal Department of Agriculture for the destruction of the woolly aphis. It consists of 2 lb. of nitrobenzene, 1 lb. of potassium xanthogenate, 40 lb. of soft soap, and 60 lb. of amyl alcohol. It is not used in the commercial condition but in aqueous solutions. With 1 lb. of Knadolin one can, according to the effect desired, prepare 1-4 gallons of liquid insecticide. It immediately moistens all the substances which it touches, which renders it superfluous to clean the trunk mechanically previously. To make sure of killing well-hidden insects, it is well, against colonies of woolly aphis, to use the insecticide only diluted with fifteen times its volume of water. Goethe remarks that Knadolin does not attack the shoots and leaves of trees like sapocarbol and lysol.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—Papasogli recommends a mixture of 5 lb. of nitrobenzene, 5 lb. of sulphuric acid, 9 gallons of water, for the destruction of this plant louse (1876-1880). The mixture is run into channels 8 inches deep between the stocks, and closed up forthwith.

Cochineals of the Olive-tree.—Mottareale advises for their destruction an emulsion which he regards as very efficient, consisting of nitrobenzene 0·25-0·5 per cent, soft soap 0·25-0·5 per cent, water 99·50-99·75 per cent.

132. Carbolic Acid, C_6H_5OH.—**Preparation.**—Carbolic acid or phenol is obtained from coal tar, in which it is present to the extent of 3-12 per cent. When tar is heated carbolic acid distils, at the same time as middle oils, between 150° and 200° C. Strong caustic soda is added to these oils, in which carbolic acid and its homologues dissolve. The liquid is treated by five times its weight of hot water; the phenols dissolve in the water, whilst the hydrocarbides remain insoluble. To obtain carbolic acid it suffices to treat this liquor by dilute sulphuric acid, and to decant. Crude carbolic acid, containing its homologues, is thus obtained. To purify it, it is washed with water, dried, then distilled in cast-iron retorts, collecting the portion which passes beween 180° C. and 190° C., and crystallizing. Rectification is not required in the case of carbolic acid used as an insecticide, for the homologues of carbolic acid are as insecticidal as itself.

Properties.—Carbolic acid is a solid body, colourless in the pure state, crystallizing in long needles. The slightest trace of water liquefies it. It is soluble in twenty times its weight of water, and volatile at the ordinary temperature. It possesses a special odour and a burning taste. Carbolic acid is a powerful antiseptic, but it is also poisonous and caustic. It coagulates albumens.

Action on Plants.—*Injurious.*—Nessler has shown that young plants die if an amount of carbolic acid more than 0·012 per cent be

added to their nutritive medium, likewise if pot plants be watered with a solution of 0·3 per cent strength. A solution of 1 per cent is pernicious to cherry-tree and peach-tree leaves. Used to disinfect corn-seed it does not lower the germinative capacity.

Action on Fungi.—As determined by Bull it requires a 5 per cent solution of carbolic acid to coagulate the white of egg, gelatine, and casein; the precipitate is not a chemical derivative but a dehydrated albumen, the carbolic acid being capable of being removed by washing. The action of carbolic acid on the spores of fungi ought, therefore, to be less energetic and more uncertain than that of copper salts which yield with albumens stable insoluble compounds. The effect of carbolic acid on saprophytic fungi such as *Penicillium glaucum* has been studied by Plugge. A solution of 1-1·5 per cent kills them. According to Neumann a 0·1 per cent solution in no way hinders the germination of their spores, a 0·2 per cent solution retards this germination, and a 0·3 per cent solution acting several times on the spores ends up by killing them. Lemaire prevents the moist mould of flour by a 5 per cent solution. Ferments are affected as follows by carbolic acid: A solution of 1-2 per cent strength interferes with the fermentation. A solution of 5 per cent strength prevents it. The action on bacteria is pronounced. Bucholz has shown that if a solution of 0·5 per cent strength interferes with their development, a 4 per cent solution prevents their multiplication.

Action on Insects.—Carbolic acid is poisonous to insects; its property of coagulating albumen puts it on the same plane as metallic salts endowed with the same property, e.g. salts of copper, silver, and mercury, but this action is weak. As Bull has shown, a solution of 5 per cent strength coagulates white of egg, a 3 per cent solution only renders it turbid, and a 1 per cent solution leaves it limpid. Gelatine and casein behave in the same way. According to Perroncito, the eggs of *Bombyx Mori*, L., still hatch after steeping two hours in a 1 per cent solution of carbolic acid.

Use.—Carbolic acid has found several uses. It is used in aqueous solution, in soapy emulsions, in admixture with silicate of soda, in absorption by sawdust, by injection into the sap of plants, and in spraying.

Use as Weed Killer.—Pammel recommends a 25 per cent emulsion of carbolic acid in water to destroy *Cnicus arvensis* (charlock of Canada). The plant is cut 8 inches underground and the young shoots produced are washed afterwards with the emulsion.

Phoma Betæ (disease of the leaves of the petiole of the beet).—Carbolic acid plays the preponderant rôle in the disinfection of beet seeds against bacterian and cryptogamic diseases. Kruger asserts a 1 per cent solution acts more surely than steeping for twenty hours in a 0·4 per cent solution of blue vitriol; for forty-eight hours in a 2 per cent bouillie bordelaise; for eight hours in a 0·02 per cent mercuric chloride, and yet it does not lower the germinative capacity of the seeds. The first experiments of 1890 made by Hellriegel consisted in steeping for twenty hours in a 1 per cent solution of carbolic acid. They yielded as a result of twenty experiments, 98 per cent of sound

beets against 13 per cent for the untreated. Steeping twenty hours has been found too long, because it causes a delay of fifteen days in the germination of the seed. By limiting the steep to fifteen hours, even whilst using a 0·5 per cent solution, the result is the same, but seeds withdrawn after ten hours only gave 50 per cent of sound plants. To facilitate disinfection, Carlson advises to soften the seed for three days in pure water of 17·5°-19° C., and only put them in the carbolic acid afterwards when it acts quicker. Tarschebinski has made numerous experiments which have confirmed those of Carlson. He found that corrosive sublimate disinfected beet seeds without previous steeping in water. Carbolic acid does not completely disinfect until after steeping of the grain; without that precaution disinfection is only relative. He also found that carbolic acid destroyed the spores of fungi much easier than bacteria. Wilfarth and Wimmer believe that carbolic acid must be completely soluble in water to give favourable results, and for that reason they prefer the crystallized acid of commerce.

Method of Disinfection.—After having perfectly dissolved the carbolic acid in water the seeds are added; they are stirred energetically to moisten them uniformly; the seeds are then pressed by boards and weights so that they are entirely covered with liquid disinfectant. After twenty hours' steeping the seeds are withdrawn and spread out in thin layers in an airy place, where they are frequently turned. The seeds so dried may be preserved as long as desired without that being injurious to them. Mark advises for the disinfection a mixture of carbolic acid and blue vitriol.

Potato Scab.—Frank and Kruger tried to disinfect the soil with carbolic acid to overcome this bacterian disease of the potato. They used an emulsion containing 250 grammes (0·55 lb.) of carbolic acid and 500 grammes of soap for a plot of 4 square metres. The result was not so good as in disinfection by petroleum.

Bacillus solanacearum (bacterial disease of Irish potato, and egg plant, *Solanum melongena*).—Sackett recommends the disinfection of potatoes and tomato seed by a 5 per cent solution of carbolic acid.

Rhizoctinia violaceæ betæ.—Eriksson found that disinfection of the soil by carbolized lime appreciably diminished the number of these fungi.

Uncinula Americana, How. (oidium of the vine).—Vesque, after experiments to overcome oidium, found that carbolic acid of less strength than 1 per cent does not destroy oidium, whilst 0·1 per cent solutions are injurious to grapes.

Use against Insects.—*Melolontha vulgaris*, L. (cockchafer).—To preserve strawberry plants from the larvæ of the cockchafer, it is advised to till along the borders and to sprinkle the hollows with a 0·1 per cent solution of carbolic acid.

Magdalis ænescens, Lec.—Against this insect which lives in the bark of the apple-tree on the Pacific coasts, Chittenden advises to coat the trunk in the springtime, up to end of May, with an emulsion of carbolic acid, lime, and soap.

Anthonomus pomorum (apple blossom weevil).—Whitehead recom-

mends against this insect spraying with a solution of soft soap 5 lb., carbolic acid 5 lb., in 100 gallons of water.

Tomicus dispar, Fbr. ("apple bark beetle," "shot-borer," "pear blight").—In Canada this insect is prevented from laying its eggs on the trunk of fruit trees by spraying on the trunks in spring a dilute solution of carbolic acid.

Halticineæ (altises).—To protect young kitchen garden plants against the attacks of altises, spraying with very dilute carbolic acid is recommended.

Atomaria linearis, Steph.—To drive off this insect from young beet plants, it suffices to disinfect the seeds as indicated on p. 345.

Eurydema ornatum, L. (decorated bug).—The red cabbage bug is overcome by dusting the leaves with sawdust steeped in carbolic acid.

Cossus ligniperda (the goat-moth).—Inject carbolic acid into the tunnels and stop the orifices.

Hyponomeuta malinella, Zell. (small ermine moth of apple-tree).—In Italy 2 per cent tobacco juice, strengthened by a little carbolic acid, is used to destroy the caterpillar of this butterfly.

Plusia gamma, L. (*gamma* moth of the cabbage).—Ashmead advises to dust the cabbage for two to three days with a mixture of phosphate of lime 20 lb., powdered lime 3 lb., carbolized sawdust 1 lb.

Schizoneura lanigera, Hausm. (woolly aphis).—Muhlberg found that carbolic acid in this form, carbolic acid 4 lb., silicate of soda 100 lb., a mixture yielding an adherent jelly, kills the woolly aphis.

Chermes piceæ and *Mindarius abietinus* (cochineals of the spruce).—Boas got appreciable results by spraying with a solution containing 1-2 per cent of carbolic acid or 3-5 per cent of lysol.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—Mouillefert declares that the phylloxera is killed by carbolic acid vapours although slowly and by contact. But carbolic acid is powerless to overcome the phylloxera on the large scale. All the methods tried to attain this end have failed; the Quehen-Mallet process, with a 0·2 per cent solution of carbolic acid; the Leonhardt process, using strong carbolic acid, laid in holes pierced around the stocks, and the Anatole process, spraying the soil round the stocks with an emulsion of petroleum and carbolic acid, have all been failures. Dr. Manchon tried an original process to poison the sap by making injections of dilute carbolic acid. Theoretically it could be granted that the descending sap carries the carbolic acid to the roots and kills the phylloxera. Henneguy shows that it is not so, as the phylloxera was not killed and the plant perished. A liquid, whether poisonous or not, absorbed by the sap may circulate with it and reach all the organs of the plant; but there are products which may be transformed by the sap itself, and consequently the insecticidal action is not felt in spots distant from the point where they were injected into the plant.

Limithrips tritici (onion thrips).—Webster found that a 1 per cent solution of phenol destroyed this thrips.

Tingis piri, Fl. (tiger of the pear-tree).—Dubreuil indicates dilute carbolic acid as efficient against this parasite.

Psylla Mali, Forst. (chermes of the apple-tree).—It is overcome by a solution of carbolic acid 0·5 per cent and soft soap 0·5 per cent.

Eriophyes ribis (phytoptus ribis, currant gall mite).—It may be overcome by a mixture of carbolic acid 3 gallons, soft soap 30 lb., in 500 gallons of water. First spraying in spring, second in autumn.

133. Trinitrophenol or Picric Acid, $C_6H_2\left\langle\begin{matrix}NO_2\\NO_2\\NO_2\\OH\end{matrix}\right.$. **Preparation.**—Picric acid is the most important of the nitrated derivatives of phenol (carbolic acid). It is obtained by heating carbolic acid with an excess of fuming nitric acid or by pouring nitric acid drop by drop into carbolic acid dissolved in sulphuric acid. Crude picric acid, which separates from the liquid after cooling, forms crystals which are collected. After draining they are dissolved in caustic soda; the picrate so formed is crystallized and decomposed by sulphuric acid.

Properties.—Picric acid crystallizes in yellow plates of a bitter taste soluble in 86 parts of water at 15° C. and in 26 parts of water at 77° C. It dissolves better in alcohol. Its salts are explosive. Picric acid is used in medicine against intermittent fever (Dujardin-Beaumetz and Clark). It has been recommended against trichinosis and the solitary worm. It is of current use in treating burns. Picric acid precipitates albumen in the same way as powerful insecticides; it is highly antiseptic.[1]

Action on Plants.—Experiments on this point are few; however, trials on the vine show that the vine supports with impunity coatings and washings of its roots. With a dose of 40 grammes per stock (616 grains) there is as yet no poisoning.

Use.—Picric acid has been tried in Germany as "Reflorit," comparatively with blue vitriol, but without success, for the disinfection of seed-corn against *Tilletia* and *Ustilago* (Sigmund, 1896; Burmester, 1908). The corn was too sensitive to its action. The results obtained by its use against mildew, oidium, cochylis, and chlorosis were negative (Colmar Experimental Station, 1908).

Action on Insects.—The action of picric acid much resembles that of "Antinnonine". The first experiments on phylloxera were made by Rommier. He found that by watering a vine in pot with 150 cubic centimetres of water containing 2 grammes of picric acid, all the phylloxera were killed in a few days. Experiments on the large scale did not give such a satisfactory result. Although each stock received 40 grammes of picric acid in solution, although this operation was followed by rains favouring the diffusion of the insecticide, and although the earth was soaked with it to such an extent that it tasted bitter, the phylloxera of the lower layers were still living eighteen days after treatment.

[1] *Translator's Note.*—All nitro derivatives and their metallic salts, more especially picric acid and picrates, are highly explosive, and their storage is attended with extremely great danger. A special licence is required.

134. Cresol or Cresylol, $C_6H_4\begin{cases}OH\\CH_3\end{cases}$.—**Preparation.**—Cresol, a methyl derivative of phenol (carbolic acid), is present in coal tar and in wood tar. It is obtained in the distillation of tar at the same time as phenol. Crude phenol is distilled and that which passes between 200° C. and 205° C. is collected. It is an oil consisting in great part of cresylol.

Properties.—Cresylol does not combine so readily with alkalies as phenol, and is less soluble in water. It is an oil which has much resemblance with carbolic acid in physical, chemical, and antiseptic properties.

Commercial Preparations containing Cresylol.—Cresylol is rarely used as such, but mostly as its sodium derivative. It is an ingredient of the best known and most efficient insecticides. These are the "sapocarbols," mixtures of crude cresylol and soap; the "lysols," mixtures of tar [oil] and soap; the "creolines," of analogous composition; "solutol," containing 15 per cent of cresylol, 45 per cent cresylate of soda, in presence of an excess of alkali; "solveol," of analogous composition but neutral; "amylo carbol," consisting of 150 oz. of black soap, 160 oz. of amyl alcohol, and 9 oz. of cresylol; "thymokresol," prepared in America; "beech tar creosote," which contains along with phenol, phorol, gaïacol, cresol, much cresylol. The composition of these various insecticides differs greatly. They contain more or less cresylol according to the source of the tars or the crude cresylols used in their preparation. Like carbolic acid they all act on insects and on plants, an action, however, which is more energetic but which varies much from one product to another, according to the source of the cresylol. There is thus much difference between the doses recommended as killing insects without injuring the plants.

135. "Sapocarbol."—This product, made in Brunswick, in Germany,[1] is a solution of homologues of carbolic acid in soaps. It is made by heating a mixture of linseed oil, rosin, and potash, and the oils collected in the distillation of crude carbolic acid, between 190° C. and 205° C., oils which contain 10 per cent of cresylol, along with xylenol, gaïacol, and other phenols. Alkali does not enter, except in the small amount required to saponify the vegetable oils, in such a way that the "sapocarbols" may be regarded as solutions of cresylols in soaps. There are several brands of "sapocarbols". Their composition, very analogous to that of the lysols, is shown in Engler's analyses. Table LXXIV gives the percentage of active ingredients which they contain.

Properties.—"Sapocarbols" are neutral; diluted with water they yield an emulsion from which the aromatic hydrocarbides separate more or less rapidly according to the amount of soap present.

[1] *Translator's Note.*—The manufacture of this class of goods is a British-born industry which originated in the first instance in sheep-dip manufacture. Both "Sapocarbol" and "Lysol" appeared on the Continent very late in the day, and neither their composition nor manufacture is based essentially on any very new principle. The only real distinctive feature is the proprietary name, and if every proprietary mixture of this sort, however meritorious it might be in itself, were to receive the special mention "lysol" and "sapocarbol" do here, the special literature would be more than unwieldy.

TABLE LXXIV.—*Showing the Comparative Amounts of Active Ingredients in Different Brands of Lysol and Sapocarbol Insecticides.*

Insecticide.	*Carbonate of Potash, Per Cent.*	*Phenols, Per Cent.*
Schenkel's sapocarbol No. 00 .	2·6	37·3
,, ,, ,, 0 .	7·7	37·6
,, ,, ,, 1 .	7·6	44·2
Lysol No. 1	5·91	44·1
,, ,, 2	6·29	46·2
,, pure	6·52	47·4

Action on Plants.—Fleischer found that sapocarbol acted as follows:—

TABLE LXXV.—*Action of "Sapocarbol" on Plants.*

Plants.	*Solution, 1 Per Cent.*	*Solution, 2 Per Cent.*
Plum-tree and apple-tree shoots and leaves . .	*Nil*	Injurious
Young shoots of the vine	Decided	Deadly
Adult leaves	*Nil*	Injurious
Nasturtium	,,	*Nil*

Solutions of "sapocarbol" above 1 per cent injure most leaves (Siedler and Koebele).

Action on Insects.—Fleischer examined the action on plant lice.

TABLE LXXVI.—*Showing the Action of Solutions of "Sapocarbol" on Plant Lice.*

Insect Species.	*1 Per Cent.*	*2 Per Cent.*
Woolly aphis, isolated . . .	Killed	Killed
,, ,, in colony . .	Partly destroyed	Destroyed almost entirely
Plum aphis	Killed	Killed
Apple ,, ...	,,	,,

Siedler, also Koebele, regard a 1-2 per cent as sufficient to destroy all plant lice. Fleischer and Keller recommend sapocarbols to kill plant lice, and even the woolly aphis; in spring, by coating the nodosities with a 2-3 per cent solution, by 1 per cent spraying in summer.

136. **"Creolines."**—Various "creolines" are differentiated:[1]—

Pearson's "Creoline" is the product obtained by the saponification

[1] *See Translator's Note to "Sapocarbol"* (p. 359).—Jeyes was the first to apply the term "creoline" to the active principle of this type of compound.

of a mixture of higher phenols and coal-tar oil containing a small quantity of pyridine bases.

Artmann's "Creoline".—Contains hydrocarbides extracted from coal tar and completely freed from phenols, German patent 51515. Whilst Pearson's "creoline" contains, along with 57-60 per cent of hydrocarbides, 22-27 per cent of phenols, Artmann's "creoline" contains 85 per cent of hydrocarbides, and only 1·5 per cent of phenols.

Properties.—"Creolines" treated by water yield an emulsion from which the hydrocarbides present therein separate after a certain time. Compared with lysols they have the great drawback of not yielding stable solutions with water. Looking to their different phenol content their action is very variable.

Action on Plants.—Fleischer tested the action of Artmann's "creoline" on plants and prepared the following table:—

TABLE LXXVII.—*Showing the Action of Artmann's "Creoline" on Plants.*

Plants.	0·5 *Per Cent.*	1 *Per Cent.*	2 *Per Cent.*
Young shoots and leaves of apple	Intact	Attacked	Greatly attacked
Young shoots and leaves of rose	Scarcely attacked	Damaged	Greatly attacked
Young shoots of vine .	Greatly attacked	Greatly attacked	Killed
Adult leaves of vine . .	Intact	Intact	Damaged
Nasturtium leaves . .	Damaged	Greatly attacked	Killed

Action on Insects.—Fleischer tried Artmann's "creoline" on plant lice:—

TABLE LXXVIII.—*Action of Artmann's "Creoline" on Plant Lice.*

Species.	*Action of a Solution of*		
	0·5 *Per Cent.*	1 *Per Cent.*	2 *Per Cent.*
Woolly aphis, isolated	*Nil*	Insignificant	Rapid
,, ,, in colonies . .	*Nil*	*Nil*	Partial
Willow aphis (naked)	Decided	Decided	Decided

Goethe found a solution of soft soap better than one of "creoline".

Use.—Disinfection of Seed Potatoes.—Mohr tried to disinfect seed potatoes with "creoline". By steeping twenty hours in a 0·2 per cent of "creoline" their germination was retarded ten days. A more concentrated solution had deadly effects. By diminishing the dose to 0·05 per cent and in adding 1 per cent of blue vitriol, not only was the germination not retarded, but the crop was heavier, say 35·2 metric tons with 13·9 per cent of starch against 21·6 metric tons with 17 per cent of starch.

Conchylis ambiguella, Hubn. (cochylis of the vine).—Numerous trials have been made. Zechini and Silva destroyed the vine-worm by a 3 per cent emulsion. They obtained the same result with an emulsion of 1 per cent of creoline and 1 per cent of nitrobenzene. Like Dufour and Fleischer they found this treatment was very prejudicial to the leaves and grapes. They therefore sought to discover other mixtures, such as:—

TABLE LXXIX.—*Showing Composition of "Creoline" Mixtures which gave Good Results against Cochylis.*

	I. *Lb.*	*II.* *Lb.*	*III.* *Lb.*
Creoline	1·5	1·5	1·5
Amyl alcohol	8	—	—
Tobacco juice	—	4	4
Soft soap	—	—	1
Water	90·5	94·5	100

These were quite satisfactory. Martini reduced the cochylis 65-68 per cent by two treatments, one in the end of April, the second in the beginning of May, with an emulsion containing 1·5 per cent of Nava creoline, 1 per cent of lime, and 1 per cent of blue vitriol.

137. Creosote [wood tar].—Creosote is a mixture of different phenols. Chemists who have studied the subject are divided in their opinions as to its constitution. According to Marasse creosote contains phenol, cresol, phlorol, gaïacol, and creosol.

Preparation.—Creosote is extracted from wood tar, chiefly beech tar, by distillation. The oily layer of the condensed liquid contains creosote. This oily layer is again distilled, only the portions denser than water are collected. When the product so obtained is treated with a solution of caustic potash the hydrocarbides remain undissolved, whilst creosote dissolves. Creosote is precipitated from its solutions by sulphuric acid. Soot contains a certain amount of creosote.

Properties.—Creosote is a refractive, colourless, oily liquid, with a smell of smoke and a burning taste. It does not dissolve in water, but is very soluble in alcohol and in alkaline lyes. Creosote dissolves resins and sulphur, coagulates the albumen of blood and of white of egg. It is a strong caustic and one of the best organic antiseptics, but it has a poisonous action, like that of carbolic acid. It is used in the state of vapour as a meat preserver, and in solution for the preservation of wood, which it preserves both from insects and saprophytic fungi. Its action on plants and insects is very analogous to that of carbolic acid.

Use.—*Merulius lacrymus*, Schum. (rot of building timber, dry rot). —"Carbolineum," consisting almost entirely of creosote, is recommended against this fungus.

Haltica (altises).—The bad smell of soot causes it to be used to drive away altises. Thiele records several failures. Mohr recom-

mends it as an insecticidal manure. The soot is spread on the field, ploughed in, and crop sown eight to ten days later.

Sitones lineatus (striped pea weevil).—It is driven off by spreading soot on the pea and haricot borders.

Ocneria dispar, L. (gipsy moth).—The mass of eggs of this butterfly are destroyed in America by the following mixture: Creosote 50 per cent, carbolic acid 20 per cent, tar oil 10 per cent, turps 20 per cent, the latter being chiefly used to dilute the creosote. This method is infallible. Experiments in America on 220 miles of land, by applying creosote on the eggs of this butterfly, followed by spraying with arseniate of lead on caterpillars freshly hatched, have been crowned with complete success, and have exterminated this formidable butterfly.

Abraxas grossulariata, L. (magpie moth).—In America soot is used to destroy the caterpillars of the magpie moth. They pass the winter under the dry leaves underneath the gooseberry bushes. These leaves are removed and the soil round the shrubs covered with soot.

Agromiza nigripes (fly injurious to lucerne).—Debray recommends to spread soot on lucerne plants to drive off the female about to lay.

Aphrophora spumaria, L. (grasshopper family).—Debray advises to destroy the larvæ in lucerne fields to cut the crop early and to spread soot on the field.

Schizoneura lanigera, Hausm. (woolly aphis).—Landry advises the use of the following mixture: Sulphur $\frac{1}{4}$ lb., soot 5 lb., tobacco juice $3\frac{1}{2}$ lb., water 5 gallons. Apply by brush on nodes and fissures infested by the lice.

Phylloxera vastatrix.—Mouillefert remarked the antiphylloxeric properties of creosote, but it does not act on the soil at a great distance, which renders its action uncertain and incomplete; besides the toxic dose for this louse kills the vine which it should protect. Lustner made experiments to determine if cresols communicate their odour to the vine, and he concluded affirmatively. Wherever cresols were used to replace petroleum in the disinfection of the vine against the phylloxera, he found that the grapes possessed the taste of cresols within a radius of 17 metres around the stock treated, a taste which is communicated to the wine in a very marked manner.

Cochineals.—Hering recommends to destroy these parasites by coating the trunks of the trees in November with pure carbolineum. This treatment does not damage the bark, but the eyes and the buds touched are destroyed. Graf Woistein concludes, from numerous experiments, that all trees coated with pure carbolineum were freed from all parasites, animal and vegetable, including *cossus*, *scolytes*, and woolly aphis. The gum of cherry-trees disappears rapidly if the treatment is repeated. Spraying with 2, 3, 8, 10 per cent solutions have no effect except when the solutions are concentrated. Spring 2 per cent sprayings have no effect.

138. "Lysols."—Preparation.—The preparation of Damman "lysols" consists essentially in mixing in fixed proportions coal-tar oils containing phenol and its homologues, with an oil such as linseed oil

or rape oil, or with a resin such as rosin, by adding a base, preferably caustic potash, in sufficient amount to obtain complete saponification. The operation is conducted in presence of alcohol, which hastens saponification and helps to render the "lysols" soluble and to impart to them a suitable consistence. The proportions in the German patent are linseed oil 10 lb., coal-tar oil 10 lb., caustic potash 30 per cent, alcohol 6½ lb.; or rosin 10 lb., tar oil 4 lb.? caustic potash 7 lb., alcohol 7 lb. Mix the linseed oil with the tar oil, add the caustic potash, then the alcohol; the mixture is heated to complete saponification in an apparatus fitted with an ascending condenser.

Properties.—"Lysols" are liquid, brownish oils, transparent, and soluble in water. Added to distilled water they form a limpid, mobile liquid, with calcareous water they are turbid. The aqueous solutions do not act on metals. "Lysols" are soluble in all proportions in ethylic, methylic, and amylic alcohol, and may be mixed with benzene. They possess a strong odour of creosote, and the antiseptic properties of phenols without their defects.

Action on Plants.—"Lysols" are poisonous to plants, but they are less irritant and caustic than carbolic acid. When absorbed by the roots they are as injurious to plants as carbolic acid. Otto showed that young maize and pea plants, raised in a nutritive media, suffered much if the latter contained 0·011 per cent of "lysol," and died if they contained 0·025 per cent. The nutritive medium in these experiments remained neutral, or slightly acid. Trials on large scale show that "lysol" used in 5 per cent solution to water soil before planting hindered the growth of the plant. A 1 per cent "lysol" is injurious to seed potatoes of one and a half hours' steep. Solutions of "lysol"—even dilute—injure aerial parts of plants if a certain strength be exceeded, which varies with the sensitiveness of the plant from 0·4-3 per cent. The most delicate plants support 4 per cent spraying; rose buds are injured by spraying with 1 per cent solutions of "lysol" and the leaves with 2 per cent solutions; the shoots of the apple-tree are burned and the apples spotted by a 2 per cent solution. Fleischer has published the following table:—

TABLE LXXX.—*Showing the Action of "Lysol" Solutions of Various Strengths on the Organs of Different Plants.*

Trees.	*Organs.*	0·25 *Per Cent.*	0·5 *Per Cent.*	1 *Per Cent.*	3 *Per Cent.*
Apple	Young shoots and leaves	Almost intact	Almost intact	Attacked	Burnt
Rose	,, ,, ,,	Intact	Attacked	Far gone	,,
Vine	Young shoots	Almost intact	Much attacked	Burnt	,,
—	Adult leaves	Intact	Intact	,,	,,
Nasturtium	Young ,,	,,	,,	Attacked	,,

Action on Fungi.—The poisonous action of "lysol" on the spores of parasitic fungi is not yet well determined. A 0·5 per cent solution

prevents the germination of the spores of black rot (Ravaz and Gouirand). It is much inferior to cupric and mercuric salts.

Action on Insects.—Perroncito found that a 1-5 per cent solution acts better on the eggs of the mulberry bombyx than a solution of corrosive sublimate of 0·5 per cent. Its energy is due to its soapy nature, which surrounds the insects and their larvæ and thus brings the insecticide in direct contact with the vulnerable parts of the insect. Insects generally succumb to a larger dose than that which is injurious to plants; thus the caterpillars of the cochylis touched by a 6 per cent solution do not die. Fleischer has summed up in the following table his researches on the action of "lysol" on plant lice :—

TABLE LXXXI.—*Showing the Action of "Lysol" Solutions of Various Strengths on Plant Lice.*

	Concentration of "Lysol" Solutions.			
	0·25 *Per Cent.*	0·5 *Per Cent.*	1 *Per Cent.*	3 *Per Cent.*
Woolly aphis treated individually	Disturbed	Killed	Killed	Killed
,, in colonies dipped in solution	Few attacked	Partly killed	All killed	All killed
Green aphis (willow) treated individually	Killed	Killed	Killed	Killed
Green aphis in colonies dipped in solution	All killed	All killed	All killed	All killed

This table shows that a solution of "lysol" of 0·5 per cent kills plant lice. "Lysol" is regarded by Fleischer as the best insecticide, and by Sturgis as greatly inferior to emerald green (Paris green).

Use.—*Sphærotheca pannosa*, Wallr. (blight of the peach and the rose-tree).—According to Schiller, Lambert, and Grübe, a solution of "lysol" of 0·5-1 per cent kills this blight. Constantin and Dufour advise "lysol" for the same purpose. The dose must be varied with the delicacy of the rose or peach-tree. Ch. Charpentier circumscribes the disease by spraying every eight days, and immediately the disease appears with a solution of 3·5-4 per cent "lysol". All the trees were not radically cured by this treatment, but the disease did not increase, and is not conveyed to the neighbouring sound trees.

Peronospora viticola, De By. (mildew of the vine).—Opinions are much divided as to the efficiency of "lysol" against mildew. In a report of the Wadenswiel Station, Switzerland, "lysol" is declared incapable of overcoming this parasite. Dufour also regards it as inefficient; it gave no result; its adherence to the leaves was also defective. "Lysol" is regarded in Switzerland as inefficient and is not used. Sipiere, on the other hand, advises its use in place of copper bouillies, and he has praised its good effects. A "lysolage" with a solution of 0·5 per cent gave him the same results as bouillie bordelaise, whilst it was also cheaper. This treatment had also the advantage of overcoming oidium

and injurious insects. The first spraying was made with a solution of 0·5 per cent, from 20-30 April. The second with 0·7 per cent solution from 1-8 May. The third with 0·1 per cent solution from 1-8 June. Solutions of 0·5 per cent are very injurious to young shoots, and 1 per cent solutions burn them; but adult leaves stand these strengths better and are not burned, except by those above 2 per cent. To increase the adherence of this product it has been advised to make a bouillie of 1 lb. of "lysol," 2-3 lb. of plaster, and $\frac{1}{4}$ lb. of silicate of soda of 33° B., in 10 gallons of water. The French "Lysol" company sells a "lysol" powder recommended against mildew, which must be used in the morning before the dew disappears.

Phytophthora infestans, De By. (potato disease).—Sturgis declares after experiments to disinfect potatoes with "lysol" that it cannot replace corrosive sublimate. "Lysol" in 1 per cent solution injures potatoes in one and a half hours' steep. Its action on the spores is *nil*.

Fusarium.—Mangin advises against fusarium to disinfect the soil with "lysol" in place of corrosive sublimate.

Guignardia Bidwelli, Viala et Ravez (black rot of the vine).—Fernbach has studied the action of "lysol" on black rot. He records the good condition of a vine coated in winter with a 3 per cent "lysol" solution and twice sprayed (1) with a 0·5 per cent solution at the beginning of vegetation, (2) with a 0·7 per cent solution at the end of May. Black-rotted leaves steeped in a 1 per cent solution for five minutes, then washed and put in contact with a healthy leaf, no longer conveyed the disease to the latter. It was the same with black-rotted leaves placed in contact with a healthy leaf previously sprayed with a 1 per cent preventive solution. Spraying and powdering done from bottom to top, so as to reach the lower face of the leaves on which the parasites preferably develop, arrest the disease in its evolution. Dieulafe advises to overcome black rot: (1) The spraying of the stems, the runners, and the pruning wounds with a solution of 2-5 per cent of "lysol," done in winter at the time of pruning. (2) Spraying at the time of coming out in leaf of the buds with a solution of 0·5-1·0 per cent. (3) Dusting from April to August in moist weather with "lysol" powder.

Mycogone perniciosa (mole disease of the mushroom).—Constantine and Dufour recommend "lysol" in 2 per cent solution for the disinfection of the frames. The process which consists in disinfection of the whole frame, as much of the soil as of its sides, gives better results than treatment with blue vitriol, boric acid, or bisulphite of lime and sulphurous acid. It prevents or overcomes other diseases of the mushroom such as the plaster (*Monilia fumicola*), gout (bacterian disease), etc.

Nectria ditissima, Tul. (canker of fruit trees).—Schiller remarks that canker of fruit trees is cured quicker by "lysol" than by tar.

Coating Trees in Winter against Insects.—Mathieu instead of liming the trunks, coats them with a solution of $\frac{1}{2}$ lb. "lysol" in 1 gallon of water.

Charæas graminis (antler moth or grass moth).—Reuter effectually destroyed the caterpillar of this noctua by watering the meadows with a 2 per cent solution of "lysol" when it begins its ravages. "Lysol" is regarded as less energetic against the caterpillars which live pro-

tected by gauze, such as the *Hyponomeuta* of the apple-tree, *Lyda Nemoralis*, cochylis, etc. Barbut, using a 10 per cent solution, could only destroy 20 per cent of the caterpillars of the cochylis and 26 per cent of the caterpillars of the pyralis.

Cheimatobia brumata (winter moth, Evesham moth).—Kraft advises "lysol" as a very effective medium to overcome this butterfly.

Eurydema oleraceum, L. (kitchen garden bug).—Lampa reports that after ten minutes these bugs are destroyed if the cabbages and beets are sprayed with a 2-4 per cent solution of "lysol".

Naked Plant-Lice.—Rossel recommends a 0·75 per cent solution to destroy the rose aphis, a 1 per cent solution to destroy that of the pear-tree and of the peach-tree. Kraf asserts that a 1 per cent solution kills all naked lice. Fleischer found that a 0·25 per cent solution even killed lice in tightly packed colonies. On the other hand, Otto commissioned by the "Lysol" factory itself to report on the efficiency of its product, reports the inefficiency of 0·25-0·5 per cent solutions on lice at the same time as their injurious action on the plants. However, the lice die in twenty-four hours when touched by a 2 per cent solution.

Schizoneura lanigera, Hausm. (woolly aphis).—"Lysol" destroys the woolly aphis, but, as Schöyen asserts, it is inferior to petroleum emulsions. Whilst Hotter regards its action as doubtful, Rossel found a 1 per cent solution perfect. Fleischer regards "lysol" as active at 0·5; at 1 per cent it destroys tightly packed agglomerations.

Cochineals.—Hertzog recommends 2 per cent "lysol" against the kermes of the rose laurel. Frank and Kruger assert that "lysol" solutions cannot kill cochineals.

Tetranychus telarius (red spider).—This acarus may be got rid of by repeated spraying with 0·25-0·6 per cent solutions (Rathay and Mussat). The browning of the leaves of the vine is overcome by spraying with 1 per cent solution of "lysol". The acari of the genus *Eriophyes vitis* especially attack the young shoots in the spring which become atrophied. Muller recommends to cut the young shoots, destroy them, and coat the whole stem with 2 per cent "lysol". *Thrips* does not resist any better.

139. Potassium Dinitrocresylate, $C_6H_2\begin{cases} NO_2 \\ NO_2 \\ OK \\ CH_3 \end{cases}$. **Preparation.**—Potassium dinitrocresylate is used in Germany for the preparation of a powerful insecticide known as antinonnine, because it is intended to destroy the caterpillar of the *Liparis monaca* [the black arch-moth which attacks pines], called Nonne in Germany and in France. Potassium dinitrocresylate is probably the crude product of the nitration of sulpho-conjugated cresylol or xylene by the action of fuming nitric acid. Dinitrocresol is converted into a potash salt, soluble in water by potash lye.

Properties.—Antinonnine, discovered by Harz and Von Miller, is a mixture of equal parts of dinitrocresylate of potash and soap. It forms a white crystalline paste soluble in water.

Action on Plants.—A solution of antinonnine of 0·1-0·125 per cent is without action on plants. When a stronger solution has to be used on the tender parts of plants, it suffices to follow up the treatment by washing twenty-four hours afterwards to prevent its action on the plant.

Action on Insects.—Antinonnine is poisonous to insects. A small dose suffices to kill them; it also acts on insects and soft-skinned larvæ; cochineals, and certain carapaceous insects, such as weevils, resist it (Hollrung). It is very poisonous to caterpillars, the larvæ of the tenthredes (saw-flies), *Nematus Ribesi*, Thorsen (gooseberry saw-fly), *Lophyrus rufus* (Schöyen), the thrips of grain crops, acari, plant lice (Taschenberg), in doses of 0·125 per cent to 0·30 per cent.

Polyporus vaporarius, *Polyporus destructor*, *Trametes cryptarum*, or *Polyporus Pini*, Pers. (red rot of the pine).—Antinonnine has been found an excellent means of destroying these fungi. Dilute solutions, only containing 0·065 per cent of antinonnine, still produce the desired effect.

Liparis Monaca, L. (the black arch moth which attacks pines), (French and German syn. *Nonne*).—Antinonnine is regarded as a specific against the caterpillar of the *Nonne*. An antinonnine solution of 0·33 per cent acts in a categoric manner after twelve to twenty-four hours; 66 per cent of the caterpillars treated were killed after twenty-four hours. By increasing the dose of soap the action is intensified.

Charæas graminis (antler moth or grass moth).—Reuter reports the good effect of a solution of ¼ lb. antinonnine and 1¼ lb. soap in 10 gallons of water, against the caterpillar of this noctua at the time when it appears in meadows.

Mice and Rats.—Antinonnine is a violent poison to rodents; 0·5 gramme kills a rabbit. For rats and mice a mixture is prepared of 10 parts of sausage grease and 1 part of sugared antinonnine. Mice die after having absorbed 0·001 gramme, and rats after ingestion of 0·02 gramme of antinonnine. It suffices to soak pieces of bread with a solution of sugared antinonnine, and to place it in winter in their holes (V. Tubeuf).

140. Thymol, $C_6H_3\begin{cases}CH_3(1)\\C_3H_7(4)\\OH(3)\end{cases}$.—**Preparation.**—Thymol is present in oil of thyme. To isolate it the oil of thyme is agitated in a strong solution of soda. The thymol is dissolved in the alkali. This liquid is separated by decantation from the supernatant cumene and thymene. The liquid obtained is diluted and saturated by hydrochloric acid which precipitates the thymol.

Properties.—In the pure state it forms colourless, crystalline lamellæ, with a sharp and peppery taste. It is but slightly soluble in water (1 in 1000), more readily soluble in alcohol and alkaline lyes. It precipitates albumen and possesses remarkable antiseptic properties.

Hypomyces Perniciosus, Magnus (mole disease of the mushroom). —Constantin and Dufour recommend a solution of 0·25 per cent to overcome the mole when the disease appears; it is necessary to remove

all the horse dung, to disinfect the premises, and to plant afresh in new dung.

141. β-Naphthol, $C_{10}H_7OH$.—**Preparation.**—To obtain β-naphthol from naphthalene it is necessary first to prepare the sodium salt of β-naphthalene sulphonic acid. It is prepared by heating together equal parts of naphthalene and sulphuric acid at 200° C. The mixture is run into water. The liquid obtained is treated with lime, boiled, and filtered. The lime salt is converted into a soda salt by the addition of carbonate of soda, filtering, and evaporating the liquid to a suitable concentration. The crystals formed are separated from the mother liquor by centrifuging, and melted with 2 parts of caustic soda and the water required to fuse the mixture. The temperature is raised gradually to 300° C. When the reaction is finished the product is dissolved in water, hydrochloric acid added, and the precipitated β-naphthol collected on a filter.

Properties.—β-naphthol crystallizes in white lamellæ; it melts at 122° C., and boils at 286° C. It is but little soluble in water, but is soluble in alcohol and alkalies. It is antiseptic.

Action on Plants.—Soluble β-naphthol, in the form of its sodic salt, burns the leaves; the insoluble salts, on the other hand, such as those of copper, iron, and lime, are not poisonous to plants.

Action on Fungi.—According to Mangin a solution of naphtholate of soda, 1 in 10,000, kills the spores of *Bremia lactucæ* (lettuce mildew) and *Heterosporium echinulatum* (fairy ring of carnations), but it is without action on those of *Nectria cinnabarina* (coral spot disease), *Peronospora arborescens*, and *Uromyces aviculariæ*.

Use.—β-naphthol is rarely used alone, but with soapy water, or in the form of a soluble salt.

β-Naphtholate of Soda.—144 grammes of β-naphthol are beaten up with hot water and caustic soda lye added to complete solution (100 grammes of caustic soda of 44° B.).

β-Naphtholate of Lime.—To $\frac{1}{2}$ gallon of a 5 per cent solution of naphtholate of soda $\frac{1}{2}$ gallon of milk of lime is added, containing 1 lb. of lime. This bouillie is recommended by Mangin as a substitute for lime for coating fruit trees.

β-Naphtholate of Copper.—4 lb. of β-naphthol are dissolved in 3 gallons of hot water, containing 0·3 gallons of caustic soda of 36° B.; $2\frac{1}{2}$ lb. of blue vitriol in 5 gallons of water are then added whilst stirring, and the whole made up to 100 gallons of bouillie. This contains naphtholate of copper, with great adherence, which does not injure the leaves (Mangin).

β-Naphtholate of Iron.—This bouillie is made like the preceding, replacing the blue vitriol by 2·7 lb. of green vitriol.

Peronospora viticola, De By. (vine mildew).—Dufour tried naphtholate of soda against this disease without success. Mangin, however, recommends a solution of naphtholate of soda, to which a little potato starch [*farina*] has been added, so as to distinguish the spots treated. Naphtholate of copper would be equally fit to combat mildew. The soda bouillie decomposes on the leaves under the influence of the car-

bonic acid of the air into carbonate of soda and naphthol which is very adherent to the leaves and resists heavy rain.

Gloeosporium macropus, Sacc. (orchid mildew).—Mangin advises use of 2 per cent naphthol; it prevents the germination of the spores.

Poppy [Œillet] Disease.—Mangin recommends to steep before transplanting the end of the slips in a solution of 15 lb. of naphthol and 45 lb. of soap in 100 gallons of water or 5 oz. of naphtholate of soda in $62\frac{1}{2}$ gallons of water (5 grammes in 10 litres).

Fusarium roseum.—Mangin advises the disinfection of the soil by a solution of naphthol 1-2400. This method is disputed by Delacroix. Sacardo advises with the same object a solution of 0·5 per cent of naphtholate of soda against rust of poppies [Œillet], rose-bushes, asparagus, etc.

142. Methyl Violet or Pyoctanine.—Pyoctanine is a methylated or ethylated rosaniline obtained either by heating rosanilines to about 140° C. with methyl or ethyl chlorides or iodides dissolved in alcohol, or by treating dimethylaniline by carbon oxichloride in presence of aluminium chloride (yellow pyoctanine is a hexamethylated auramine).

Properties.—Methylated and ethylated rosanilines in the form of salts constitute crystallized violet colouring principles soluble in water. They are used to make aniline inks, and in the dyeing of fabrics. Pfeffer determined the injurious action of pyoctanines on phanerogams. Kreminski, and especially Stilling and Wortmann, have examined the antiseptic action of pyoctanines. They have shown that it suffices to sterilize a medium, such as meat juice, for it to contain 0·005 per cent of methyl violet, or 0·5 per cent of yellow pyoctanine. The *Staphylococcus pyrogenus aureus* does not develop in a solution of 1 in 2,000,000 of methyl violet. The *Penicillium glaucum* does not develop in a medium drenched with a solution of 1 in 10,000 of pyoctanine violet. The pyoctanines do not coagulate albumens, like powerful antiseptics such as corrosive sublimate, formol, etc., but albumenized bodies have a certain affinity for these products and eliminate them from water whilst becoming dyed. The colour concentrates itself there, and if the amount absorbed is sufficient the corpuscles are arrested in their evolution, the dyed bacteria give up their colour to pure water, and they can become completely decolorized and regain by this fact their primitive vitality if the surrounding water is in sufficient quantity to extract the colour simply dissolved in their plasma.

Use.—*Acrostalagmus albus.*—Stilling found that it sufficed to water the infected dung or the dunged borders with a dilute solution of methyl violet to stop the development of this fungus.

CHAPTER XXIV.

CARBON COMPOUNDS (*continued*)—TOBACCO (NICOTINE TOBACCO JUICE)—QUASSIA—HELLEBORE—PYRETHRA—DELPHINIUM (LARKSPUR)—STRYCHNINE—NUX VOMICA—WALNUT LEAVES—GLUE—CUTCH—ALOES.

143. **Tobacco.**—Tobacco is furnished by plants originally natives of tropical America now acclimatized in all countries, chiefly *Nicotania tabacum* and *Nicotania rustica*, L. When ripe the leaves of these plants are collected and dried in drying machines. The green leaves contain 1·5-9 per cent of nicotine, the dry leaves up to 4 per cent.

Tobacco powder [? snuff] is made from greasy tobaccos. The leaves are moistened with salt water, then cut into thongs and laid in heaps of about 40 tons. Fermentation sets in; after four months the tobacco is conveyed to mills. It is moistened again and piled up to undergo a second fermentation which lasts eleven months. Tobacco juice is obtained in the tobacco manufactories by treating the coarsely divided leaves with boiling water. The liquor obtained is filtered and evaporated to the right strength, then the substances injurious to plants are removed. In France the culture, manufacture, and sale of tobacco are the subject of a monopoly exploited by the State. The Minister of Agriculture publishes special sheets of information sent to the Mairies (Town Halls), giving the price and the strength in nicotine of the juice sold by this administration. The old juices are differentiated from the new or rich juices; the latter are five to six times stronger than the former. The French tobacco administration now delivers the latter with up to about 10 per cent of nicotine. They are sold to the public in tins in the tobacco markets and in warehouses. Tobacco juice enters into many insecticides to strengthen their action. A few examples only will be quoted. To impart adherence to these insecticides gum-arabic, sugar, etc., is added.

Insecticides with a Tobacco Basis.—(1) 5 lb. tobacco juice, 1 lb. soft soap, in 100 gallons of water. (2) Dissolve 4 lb. soft soap in 10 gallons of water, then add, whilst constantly stirring, 6 lb. of tobacco juice, 5 lb. of amyl alcohol, and 20 lb. of ordinary alcohol (Nessler). (3) Dissolve 2½ lb. of soap in 2 gallons of hot water, add 1½ lb. of amyl alcohol. Run into this liquor a decoction of 3 lb. of tobacco juice in 8 gallons of water (Nessler). (4) Water 100 gallons, rich juice, 10 per cent, 1 gallon, soft soap 10 lb., commercial carbonate of soda in crystals 2 lb., methyl alcohol 1 gallon. The soap increases its adherence and the wood spirit appreciably increases the action on certain parasites. (Note of the French Minister of Finance regarding tobacco juice drawn from the National factories for the destruction of

insects.) (5) Add to a 2 per cent tobacco juice a little carbolic acid. (6) Add to 4 lb. of the above carbolized tobacco juice $1\frac{1}{2}$ lb. of creoline, 1 lb. of soft soap dissolved in 10 gallons of water (Zechini and Silva). (7) Dissolve 3 lb. of soft soap, in 5 gallons of water, add thereto a solution of $2\frac{1}{2}$ lb. of blue vitriol, neutralize by 11 lb. of caustic potash. After stirring well run in $5\frac{1}{2}$ lb. of tobacco juice and $2\frac{1}{2}$ lb. of "creoline".

Properties.—Tobacco juice is characterized by a special alkaloid nicotine. Pure nicotine is an oily liquid, colourless, soluble in water, alcohol, and fatty oils; it precipitates almost all metals from solutions of their salts; with copper it yields a green precipitate soluble in a large excess of nicotine. Nicotine is a violent poison to mammals. A single drop of nicotine suffices to kill a dog. It causes giddiness, abdominal pains, followed by death in a few minutes.

Action on Plants.—Tobacco juice is used as an insecticide in 1 per cent doses, say 0·1 per cent of nicotine. It injures plants; mixtures with soap still further increase its injurious action. To obviate this drawback it is necessary to follow the sprayings by careful washing after one hour's interval. Fumigations in greenhouses are less to be feared for the plants; however, Decaisne has observed that certain greenhouse (*serre froide*) orchids stand this treatment badly.

Action on Insects.—Nicotine is a violent poison for most insects and their larvæ. Chittenden observed that it did not act so on all insects. A solution of 0·1 per cent (1 per cent of the rich juice of the French manufactories), especially if it contains 1 per cent of soap, forms an energetic liquid against the most diverse insects. If the published results do not always agree that is due to the different nicotine content of the juices tested on the same insects. It is agreed that nicotine solutions have a specific action on the caterpillars of butterflies, the false caterpillars of the saw-flies, on non-protected lice, thrips, and acari. In closed spaces the action of the vapours of nicotine is drastic even on cochineals.

Use.—In enclosed spaces, greenhouses, or spaces covered in for the purpose, the following process is used to obtain entire disinfection of the plants therein:—

Fumigation or Evaporation of Nicotine in a Closed Space.—It is carried out in different ways: (1) Tobacco is laid in a special apparatus outside the greenhouse above red-hot coals, the combustion of which is accelerated by a bellows. A pipe leads the vapours charged with nicotine inside the enclosed space. (2) Moisten tobacco leaves and place them on the hot pipes of the hothouse. The water evaporated carries sufficient nicotine to kill the insects. (3) Slow evaporation inside the greenhouse of tobacco juice placed on small stoves. (4) Projection of tobacco juice on strongly heated bricks or irons.

Use in Open Air.—Open-air plants infested by insects are sprayed with tobacco juice diluted with water to contain 1 per cent of rich juice. Nicotine solutions not moistening sufficiently the insects touched it is better to use soapy bouillies which adhere and moisten much better and thus act more quickly. After one hour the insects touched are dead; the plants treated must then be washed to prevent the deadly action of the nicotine and the soap on the plant.

Tobacco powder spread by the bellows on the insects is very efficient, and in many cases it is more active than pyrethra powder.

Haltica ampelophagus, Guer. (altise of the vine).—In the opinion of d'Aurelles de Paladines tobacco juice of 3° B. black snuff mixed at the rate of 12-15 per cent with Apt sulphur, a mixture of 1 per cent of rich juice, 1 per cent of petroleum, and 1 per cent of soap forms an insecticide which destroys the altise of the vine. Von Schilling regards tobacco infusion as the most efficient medium against the altise if the spraying be renewed after each rain. Thiele observes that these preparations have no action on the altise unless the insects are touched by the liquid; the insecticide coatings which cover the leaves after treatment do not remove the altise, hence the necessity of multiplying the treatments to obtain a favourable result.

Altise of the Gardens.—When young plants commence to shoot up they are copiously watered and then wood sawdust strongly soaked in dilute tobacco juice is spread over the whole of the seedlings.

Crioceris Asparagi, L. (the asparagus beetle).—Blin recommends as very energetic a mixture of 10 lb. of tobacco juice infused in 30 gallons of boiling water, and 2½ lb. of soft soap; 66 gallons of this mixture suffice for 2000 asparagus plants. This treatment completely destroys the larvæ.

Crioceris melanopa, L. (crioceris of cereals).—Sajo recommends tobacco juice, used as spray on infested fields. The following are the results of a trial made with a solution of 20 lb. of tobacco juice, testing 14·5 per cent of nicotine in 10·6 gallons of water.

TABLE LXXXII.—*Action of Tobacco Juice on Crioceris of Cereals.*

	Barley in Lb.
Plot treated with 154 gallons of this solution . .	199
Untreated plot	78·1
Immune plot	215·6

There is no doubt of the good effect of this treatment. The operation is best done at the moment the larvæ are hatched. At that time the field is sprayed in the direction of its width, then it is sprayed in the direction of its length.

Rhynchites Fragariæ.—This insect which cuts the strawberry leaves is overcome by tobacco juice (0·5 B.), (Ernest).

Zabrus gibbus (*carabe bossu*), (cereal zabrus).—Three per cent of Hungarian tobacco extract in 100 litres of water are perfectly capable, according to Sajo and Naszay, of destroying this insect and its larvæ in wheat fields. The treatment is applied in the month of April; the stimulating effect is at once seen in the improvement in the growth of the plant.

Cassida viridis (artichoke tortoise beetle).—Its larva gnaws the leaves of the artichoke. Debray destroys it by tobacco infusion.

Sitones lineatus, L. (the striped pea weevil).—Noel advises tobacco juice 0·5° B., and containing 1 per cent of soft soap.

Ocneria dispar (bombyx dispar, gipsy moth).—Berèlse destroyed in five days 100 per cent of the caterpillars of this butterfly with a 5 per

cent juice; with a 2 per cent carbolized juice he only killed 80 per cent of the caterpillars.

Abraxas grossulariata, L. (magpie moth).—Soapy solutions of tobacco juice free gooseberry bushes from the caterpillars of the magpie moth.

Conchylis ambignella, Hubn. (cochylis of the vine).—Nessler's insecticides with a tobacco basis (formula No. 3) is perfect to destroy the caterpillar of the cochylis. Zechini and Silva advise for the same purpose their insecticide (formula No. 6). Jemina proposes his insecticide (formula No. 7) to overcome simultaneously both the cochylis and mildew.

Hyponomeuta malinella, Zell. (small ermine moth of apple-tree).—Sonnino praises 2 per cent carbolized tobacco juice.

Pentatoma (*Carpocoris*) *baccarum*, L. (bug injurious to fruit trees). —Taschenberg recommends to spread moist cloths in front of the fruit walls, and to fumigate with tobacco between these and the walls as is done in greenhouses.

Eriocampa adumbrata (slimy caterpillar, slug-worm).—Bach records the good effects of tobacco powder spread on the larvæ. Tobacco juice at the rate of 2 lb. of juice, with 14·5 per cent of nicotine in 10 gallons of water is regarded by Sajo and Czerhati as an excellent method of destroying the slug-worm.

Nematus ventricosus, Kl.; *Emphytus Grossulariæ*, Fb. (gooseberry and currant saw-fly).—To get quit of this insect Ahlisch advises spraying with a liquor consisting of 2½ gallons of tobacco juice, 5 lb. of soft soap, and 40 gallons of water.

Lophyrus pini (the pine saw-fly).—Sajo advises to destroy the larva of the pine saw-fly by spraying with a solution of 2 lb. of tobacco juice containing 14·5 per cent of nicotine in 10 gallons of water.

Diplosis rosiperda.—This rose cecidomia (fly), the larvæ of which is in the rose shoots, is fought in greenhouses by fumigation with tobacco (Chittenden).

Unprotected Plant Lice.—Plant lice are very sensitive to tobacco juice. A solution of 0·1 per cent of nicotine, say 1 per cent of strong tobacco juice containing 10 per cent of nicotine of the French State factories, suffices to obtain a satisfactory result. However, the nature of the lice prevents this liquid from moistening them, and these sprayings only reach a small portion. To remedy this drawback, it suffices to dissolve in the nicotine solution 1 per cent of soft soap. Laurent advises soft soap and carbonate of soda. In these conditions the liquid at once reaches the lice, which die forthwith. The operation must often be repeated, especially, as is frequently the case, when the lice have made protective shelters by deforming the leaves, as is the case with the gooseberry and peach louse. The soapy and alcoholic solutions (formulæ Nos. 3 and 4) are still better.

Schizoneura lanigera, Hausm. (woolly aphis).—Nessler's solution (formula No. 3) is advised for the destruction of this aphis. According to the researches of Stedman it would follow in an irrefutable manner that the woolly aphis extends its ravages to the underground part of the apple-tree; to completely destroy the aerial colonies the roots must

be disinfected at the same time. Gillette has studied the effects of powdered tobacco [? snuff] in this particular instance. It is now regarded just as it is bought as an infallible specific for the destruction of the underground form of this louse. Powdered tobacco mixed with earth is frequently used in nurseries and also for other crops.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—Mouillefert found tobacco juice destroyed this aphis.

Tingis Piri, Fl. (tiger of the pear-tree).—Sajo advises 2 lb. of tobacco juice containing 14·5 per cent of nicotine in 100 gallons of water as a means of radically destroying the tiger, but care must be taken to direct the jet on the lower surface of the leaves.

Pulvinaria vitis, L. (*Coccus vitis*), (vine scale).—Targioni-Tozzetti advises to destroy the mobile larvæ of this cochineal by spraying with tobacco powder or using powders with a nicotine basis. Mohr praises the effects of the following mixture deadly to cochineals in general: Add 25 lb. of soft soap, 20 lb. of ammonia, 20 lb. of oleic acid per 100 gallons of tobacco juice. Guozdenovic records the good effects of a mixture of 1·5 per cent of tobacco juice and 0·5 per cent of soft soap against the *Dactylopius vitis* (white cochineal of the vine).

Thrips hæmorrhoidalis, Bché. (black thrips of greenhouses or black fly of the gardener).—It infests plants in greenhouses, and under cloche, such as azaleas, camelias, fuschia, and causes them to fade. It may be overcome, according to Decaisne, by powdered tobacco and fumigations. Noel advises to soak the residues from the manufacture of tobacco in a solution of 2 lb. of nitrate of potash in a gallon of water and then dry it and burn it in the hothouse.

Limithrips Tritici (thrips which ravage onions).—It may be destroyed, according to Webster and Rathay, by a decoction of tobacco.

[Animal and plant lice are effectively treated by tobacco juice.]

Phyllocoptus Schlechtendali, Nal. (browning of the leaves of the pear-tree).—This acarus may be destroyed, according to Sirodot, by tobacco juice marking 1·5° B. and sprayed on all the parts of the tree.

Greenhouse *acari* do not stand fumigation (Decaisne) nor spraying with the mixture of ammonia, tobacco juice, soap, and oleic acid to be used against vine scale (Mohr).

Tetranychus telarius (red spider).—Rathay kills this tree louse with tobacco juice.

Tetranychus althaeæ (Tetranychus which causes the rusting of the leaves of the hop), (Kupferbrand). It is overcome, according to Voss, by preventive treatment. In the autumn the soil is dusted with powdered tobacco [? snuff]. Spraying with tobacco juice has little effect on adult tetranychus living on the plant (Sorauer). Voss' method is preventive. It kills the tetranychus which hibernate under the leaves on the hop fields and prevents the return of the disease.

144. Quassia Amara [**true.**]—Quassia is derived from a Guiana tree, the quassia tree [*Quassia Amara*]. The quassia of the shops is the wood of *Picrena Excelsa*, belonging to the family of *Simarubiaceæ*. The wood and the roots are sold as chips or lumps (*Lignum Quassicæ*). To extract the quassia the chips are macerated for twenty-four hours in water. Insecticides with a quassia basis are prepared thus: (1) Boil

on the one hand, 5 lb. of quassia chips in 50 gallons of water; let stand for twenty-four hours and decant the extract; on the other hand, dissolve 5 lb. of soft soap in 50 gallons of water. Mix the two liquids. (2) 7½ lb. of quassia are macerated and 3½ lb. of soap are dissolved in 100 gallons of alcohol (Alvood). (3) 1½ lb. of quassia are macerated in water, heated to boiling and decanted; after twenty-four hours a solution of 2½ lb. of soft soap is added and the bulk made up to 10 gallons (Klein). (4) Dissolve 10 lb. of soft soap in 5 gallons of hot water, add thereto an infusion of 2½ lb. of quassia chips obtained by twelve hours' steeping in 5 gallons of rain water; make up to 40 gallons (Koch's insecticide). (5) Emulsify 5 gallons of petroleum in a solution of 6 lb. of soft soap in 50 gallons of water (see petroleum), and add thereto an extract of 10 lb. of quassia in 50 gallons of water. (6) Add 4 lb. of carbolic acid to a mixture of 5 lb. of quassia extract and 6 lb. of soap in 100 gallons of water (Gilardi).

Properties.—Quassine, the active principle of *quassia amara*, is amorphous or crystalline. It has been isolated by Winkler. It is colourless, inodorous, opaque, and inalterable in the air, slightly soluble in water, much more soluble in water charged with salt or organic acids, and in alcohol. To man, quassine is not poisonous, it is toxic, aperient, and stomachic. In doses of 4-10 centigrammes per day, quassine has no injurious effects on man; on the other hand, it is deadly to the lower animals—oxyures, ascarides, etc.

Action on Plants.—Plants are not injured by spraying with aqueous extracts of quassia; on the other hand, extracts mixed with soap are injurious to certain plants, especially if soft soap be used and if the dose is superior to 1 per cent. Fleischer prepared the following table on this point for Klein's solution (No. 3 supra):—

TABLE LXXXIII.—*Showing the Action of Klein's Solution (3) on the Organs of Various Plants.*

Plants and their Organs.	*Action.*
Shoots and leaves of the apple-tree	Hardly attacked
Leaves of the plum	,, ,,
Vine	Unattacked
Nasturtium	Greatly damaged

Action on Insects.—No insect can live in boxes made of quassia wood (Wright); fly-paper is blotting-paper soaked with a sugared extract of quassia. Quassia insecticides act on soft-skinned, non-protected insects, on their larvæ, on caterpillars, plant lice, and phytotides. Koebele regards quassia extracts as less active than fish-oil emulsions.

Use.—*Caterpillars of Fruit Trees.*—Insecticide (5) is recommended by Gilardi as an excellent medium for destroying various caterpillars which infest fruit trees.

Conchylis ambignella, Hubn. (cochylis of the vine).—Insecticide No. 1 is regarded by Gilardi as sufficient to destroy the caterpillar of the cochylis.

Unprotected Plant Lice.—Plant lice are very sensitive to quassia extracts. Whitehead recommends insecticide No. 1 against the hop aphis and the wheat aphis; Klein and Fleischer insecticide No. 3

against green aphides and even against the woolly aphis. Mohr the insecticide No. 1 against the aphis of the peach and of the gooseberry, to be used when the leaves begin to uncurl.

Phylloxera vastatrix, Pl. (phylloxera of the vine).—Mouillefert regards quassia as inefficient against this louse. In Germany, Schmidt has taken out a patent, D.R.P. No. 50772, for a mixture to be used to destroy the phylloxera of the vine, the composition of which is methyl alcohol 30 parts, turpentine 10 parts, extract of quassia 3 parts, or methyl alcohol, 60° Tralles, 10 parts, carbonate of potash dissolved in water 1 part, quassia extract 1 part, phosphoric acid, 20° B., 1 part.

Phytoptus Ribis, W.—A liquor made from 4 lb. of quassia chips and 3 lb. soft soap, in 50 gallons of water, used as a spray in the spring and in the autumn as soon as the fall of the leaf, destroys these insects.

Phytocoris militaris, Westwood (orchid bug).—Staes has shown that tobacco powder had no action on this bug, but that, on the contrary, a decoction of quassia with soft soap destroyed them.

145. Hellebore Root.—Hellebores, plants of the family Renonculaceæ, contain a bitter substance which imparts to them violently drastic properties and renders them poisonous in large doses. It is chiefly the roots which contain this principle.

Preparation of the Liquid Insecticides.—(1) 5 to 7½ lb. of finely pulverized hellebore roots are stirred up in 100 gallons of water; this bouillie is used such as it is without being decanted. (2) The powder obtained by finely pulverizing white hellebore roots is diluted with up to 10 parts of flour; at the fall of the dew it is spread on the plants by means of a bellows or through a muslin bag. (3) Make a decoction of 1 lb. of hellebore root and let it stand twenty-four hours. (4) Emulsify 60 fluid oz. of paraffin oil with a solution of 120 oz. of soft soap in 10 gallons of water, then incorporate 40 oz. of hellebore root (Whitehead).

Action on Insects.—Hellebore root is a violent poison to insects which gnaw leaves, it acts like arsenical salts and is used in their place.

Use.—Insecticides Nos. 1 and 2 appear according to Whitehead and Riley to be specific against:—

Eriocampa adumbrata, *Eriocampa cerasi* (the slimy caterpillar, slug-worm).

Nematus Ribesii, Scop. (gooseberry saw-fly).

Cladius pectinicornis, F., *Emphytus cinctus*, L., *Monostegia Rosæ*, H. (rose saw-fly).

Abraxas grossulariata, L. (magpie moth).—Emulsion No. 4 is recommended by Whitehead against *Psylla*, *Anthonomus pomorum* and *Schizoneura lanigera* (woolly aphis).

Sparrows.—To poison sparrows, it suffices to place a handful of hellebore powder in 1 quart of water and boil grains of wheat therein. The sparrows eat them without suspicion.

Rodents.—Constantin Cesar recommended in 1543 to place in rat holes during great heats (1) a mixture of rye grain, barley-meal, and hellebore, or (2) a paste made by grinding equal parts of bitter almonds and hellebore, and afterwards mixing with barley-meal and oil.

146. Pyrethra.—The pyrethras, plants which belong to the family of Compositæ, contain an insecticidal principle. Two plants are chiefly used to make pyrethra powder or bug powder; these are *Pyrethra cinerariæ-folium*, Treviv., and the *Chrysanthemum coccineum*, Willd. A species originally Caucasian, *Pyrethrum roseum*, contains less active principles. Although cultivated in Asia, insecticidal pyrethra can accommodate themselves to the South of France. Their culture might produce excellent results with a profitable yield.

Preparation of Pyrethra Powder.—The flower, the sole organ of the plant containing the insecticidal principle, is alone ground. According to certain authors the best powder is made from unexpanded flowers; others say that the flower-bud must be perfectly closed, whilst others assert that the flowers should be collected when the flower is in full bloom. Pyrethra powder is made in America, Great Britain, Germany. Montenegro exports into these countries 10 tons of pyrethra flowers per annum. Pyrethra powder is none other than the dried flower suitably and finely pulverized. It is used most often alone, such as it is; sometimes it is mixed before use with three times its weight of flour, or with four times its bulk of sulphur to destroy both the altise and the oidium of the vine, or again with cupric sulphosteatite to destroy the altise and the mildew.

Preparation of Pyrethra Extracts.—1. *Aqueous Extracts.*—6 lb. of pyrethra powder are treated cold with 10 gallons of water. Maceration lasts twenty-four hours. It is easier to make the extract by aid of heat. The pyrethra powder is first made into a paste by hot water, it is thinned down gradually with boiling water and cooled. Before use this extract is diluted with six to eight times its volume of water without losing its insecticidal properties.

2. *Soap Extract.*—Dissolve 3 lb. soft soap in 1 gallon of hot water; add thereto whilst stirring with a birch-broom $1\frac{1}{2}$ lb. of Dalmatian pyrethra powder and 9 gallons of cold water. Invented by Dufour of Lausanne, this insecticide is one of the most perfect now existing.

3. *Alcoholic Extract.*—Treat 6 lb. of pyrethra powder with 10 gallons of 80 per cent alcohol. Dilute before use with 5 parts of water.

4. *Alcoholic and Ammoniacal Extract.*—Mohr mixes in a flask 100 grammes of Dalmatian pyrethra powder, 200-250 grammes of alcohol, 80-100 grammes of commercial ammonia. After some days he adds $1\frac{1}{2}$-2 litres of water, and heats gently for forty-eight hours. [Similar proportions in the same ratio are 1 lb. pyrethra powder, 2-$2\frac{1}{2}$ lb. alcohol, 0·8-1 lb. commercial ammonia, and $1\frac{1}{2}$-2 gallons of alcohol.] The liquor is filtered and mixed as follows:—

TABLE LXXXIV.—*Showing Composition of Pyrethra Insecticides.*

	No. 1.	*No.* 2.
Extract	3 lb.	5 lb.
White soap	$2\frac{1}{2}$,,	5 ,,
Non-calcareous water	10 gals.	10 gals.

Preference must be given to one or other of these insecticides according to the resistance of the insect to be killed.

5. *Cupric Insecticide Bouillie.*—Treat by boiling from five to ten minutes or by maceration for twenty-four hours in the cold, 3-4 lb. of pyrethra powder in 10 gallons of water, and mixing this extract with a cupric bouillie by running it into the concentrated bouillie. This bouillie has the advantage of acting both on the mildew and the altise of the vine simultaneously.

6. *Alcohol and Carbon Disulphide Extract.*—Treat 7 oz. of pyrethra powder by maceration for eight days in a mixture of 7 oz. of ether, 25 oz. of carbon disulphide, and 75 oz. of alcohol, 86° B. (all by weight). Filter afterwards (Pratigeon).

7. *Pyrethra-petroleum Emulsion.*—Emulsify petroleum in an aqueous pyrethra extract. This emulsion is recommended by Webber against cochineal.

Properties.—Pyrethra powder forms a very fine light powder, the insecticidal principles of which are volatile. Old powders are dead and inert.

Action on Plants.—Pyrethra powder has the great advantage over insecticides, such as petroleum, carbolic acid and others, of having no injurious action on the leaves; even the soapy extracts if they do not contain too large a dose of soap are without injurious action on plants (Fleischer).

Action on Insects.—The intensity of the action depends on the freshness of the pyrethra powder. The insecticide action of the powder sold under the name of bug powder has been known for a long time. If it be not preserved in a well-closed bottle, its insecticidal power departs; moreover, its action is of very short duration, the active principles being very volatile. Carapaceous insects are generally insensitive to this insecticide; it is not so with soft-skinned insects and larvæ not protected by a hairy down, these succumb readily. The different soapy and alcoholic extracts are much more active owing to the substances which they contain, which moisten the insects touched more perfectly than aqueous extracts.

Use.—As powder pyrethra is in domestic use to treat plants in pots infested by lice and to free them from vermin. The extracts would find an extensive use if they were cheaper and their action less variable according to whether the pyrethra bought is fresh or old.

Leptinotarsa decemlineata (Colorado beetle).—Alvood found that if the powder is inert against adult insects, it kills 50 per cent of the larvæ.

Saperda Populnea, L. (the poplar borer).—To destroy the larvæ of this Coleoptera, Mohr advises to inject his extract No. 4 (p. 378) into their burrows by means of a caoutchouc drill guided by an iron wire. The amount should be such that the liquid flows from the orifice. After a quarter of an hour all the larvæ leave the holes and can be crushed. The same process is used to destroy the caterpillars of *Cossus* and of *Sesia*; the latter dies in the holes.

Haltica ampelophaga (altise of the vine).—Pyrethra is regarded as an excellent medium for getting quit of the altise of the vine, and altises in general, 12-15 per cent of pyrethra powder with ordinary sulphur or Apt sulphur to overcome simultaneously the oidium and

altises. Gervais advises to mix pyrethra powder with "Cupric-sulphosteatite". Two applications suffice to get quit of this minute insect. Pyrethra extract may likewise be added to cupric bouillies. The extract alone is used at 4 per cent strength. Debray, Prosper, Gervais, Lecq, and d'Aurelles de Paladine report the terrible action of mixtures containing pyrethra. Taschenberg and Montillot advise to kill in a general way all earth lice by using mixtures of pyrethra powder and naphthalene; naphthalene 2 lb., pyrethra powder 1 lb., or pyrethra powder alone.

Lema melanopus, syn. *Crioceris melanopa* (crioceris of cereals).—To kill the larvæ of this insect injurious to grain crops in Hungary, Sajo recommends to spray copiously with aqueous pyrethra extract. This process destroys 75 per cent. Nicotine is regarded as more active.

Entomoscelis adonidis, Pall.—Sajo advises 2·5 per cent pyrethra extract to destroy rapidly the larva of this insect which gnaws the leaf of the beet.

Conchylis ambignella, Hubn. (cochylis of the vine).—The soapy extract of pyrethra with 3 per cent of soap was recommended (p. 378) by Dufour to kill the caterpillar of this butterfly. The first spraying must be given before flowering, when the caterpillars have just hatched, and the second after flowering. In the opinion of Perraud, Berlèse, Silva, Bononi, Nestore, Peglion, and Del Quercio it is one of the best means of killing the red-worm of the vine. It has, however, the disadvantage of being dearer than other insecticides. Sirodot recommends its application by a spraying machine, with an intermittent jet, which is directed on to the grapes morning and evening in the month of July.

Carpocapsa pomonella, L. (codlin moth).—Mohr recommends his No. 2 extract (p. 378) applied before flowering, to destroy the young caterpillars of this pyralis.

Eriocampa adumbrata (slimy caterpillar, slug-worm).—Dufour's soapy extract of pyrethra (p. 378) gives good results in the destruction of the slimy caterpillar (Siedler).

Hylotoma rosarum, Fabr. (hylotome of the rose).—Mohr recommends his No. 1 extract (p. 378) against the false caterpillar of this saw-fly. Taschenberg reports the good results from a mixture of 66 per cent of pyrethra powder and 33 per cent of naphthalene against the larvæ of saw-flies in general.

Athalia Spinarum (*Athalia centifolia*), [the turnip saw-fly, black caterpillar, blacks, canker, black palmer, nigger or black grub], Fabr.—This saw-fly, the larvæ of which ravage the leaves of beets, may be destroyed, according to Burki, by an aqueous mixture of 4 per cent of soft soap and 1 per cent of extract of pyrethra powder.

Lopus sulcatus, of which there was an invasion in 1889 into the departments of Indre and Yonne, may be destroyed, according to Pratigeon, by the alcoholic and carbon disulphide extracts of pyrethra referred to above.

Diplosis rosivora.—This rose-fly gnaws the shoots of the rose-bush, especially those of La France, Meteor, and Wooton. Chittenden recommends pyrethra powder to combat it.

Diplosis violicola, Coq.—It is killed in the same way (Chittenden).

Ants.—Taschenberg recommends to kill them with a mixture of pyrethra powder and naphthalene. Mohr advises his extract (p. 378) at the rate of 30-35 fluid oz., diluted with 250 fluid oz. of water and poured on the ant nest in the morning before the ants come out. In light soils and with large ant nests, it is necessary to pour 1-2 litres of this liquor, say 1 to 2 quarts.

Schizoneura lanigera, Hausm. (woolly aphis).—Grossbauer recommends to destroy this parasite with a mixture of soft soap $7\frac{1}{2}$ lb., pyrethra powder $2\frac{1}{2}$ lb., in 100 gallons of water. Muller found this liquor less energetic than Nessler's insecticide at $\frac{1}{10}$.

Naked Plant Lice.—According to the experiments of Fleischer, the soapy extract kills them easily. Hotter recommends the powder, because it can penetrate into the twisted, rolled, and deformed leaves which serve as a refuge to many plant lice and surely reach the latter.

Psyllas and *Phytoptides* (gall mites) are destroyed in the same way.

Slugs.—Mohr recommends his extract No. 2 (p. 378) to kill slugs.

147. Strychnine.—Strychnine is an alkaloid which is contained in certain plants such as the nux vomica tree, which yields nux vomica, and the walnut-tree.

Use.—*Spilographa Cerasi*, F. (cherry-tree fly).—Water the soil around the trees after the fall of all the wormy cherries with a hot decoction of walnut leaves that kills the grubs buried at a slight depth in the soil (Taschenberg).

Plant Lice.—Kasebier recommends the following liquor to get quit of these lice: Make an extract of rasped nux vomica nuts by passing them three to four times into hot water, then letting them macerate some hours. To preserve this extract, $\frac{1}{10}$ per cent of denatured alcohol (meth. spirit) is added to it when about to be used; to strengthen its action 1 per cent of "sapocarbol" is added to it. No insect, it would appear, frequents a tree sprayed with this liquid insecticide.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—Syringing with strychnine solutions (Mourgue's process) had no more effect on this louse than an infusion of $\frac{1}{2}$ lb. of walnut leaves in a gallon of water (Chevalier's process, 1872), or of $\frac{1}{4}$ lb. of walnut leaves in a gallon of water (Panet's process, 1872).

Peach and Gooseberry Aphis (*Aphis persicæ*).—An infusion of nut leaves collected in autumn destroys these plant lice, especially when it is strengthened by a little soap. Mohr advises to spray as soon as the leaves begin to curl and twist; he sprays twice.

Sparrows.—Granivorous birds may be prevented from devouring corn-seed by dipping the latter into a bath containing strychnine; dissolve 10-15 grammes (say $\frac{1}{3}$ to $\frac{1}{2}$ oz.) of strychnine in the water required to cover entirely 1 kilogramme (2·2 lb.) of seed; steep the grain for two hours, stirring occasionally, then withdraw it and dry it. Kruger remarks that if the birds devour it the first day none reappear the following days.

Talpa europea (mole).—To destroy moles it suffices to cut up earth-

worms into pieces and to roll them in nux vomica powder, and to place them in their burrows.

Rodents.—It is advised to poison wheat by strychnine, and to place it in pipes in proximity to the burrows of the rodents. The pipes prevent birds from being poisoned.

148. **Delphinium** (larkspur).—The extract from the stems, leaves, and seeds of the larkspurs, especially that from the seeds of *Delphinium grandiflorum* and *Delphinium ajacis*, is recommended for the destruction of insects. Powdered larkspur seeds are used in medicine to destroy vermin in the head and to cure skin diseases; extract of larkspur taken internally is drastic, emetic, aperient, diuretic, and vermifuge. Laboulbene advises larkspur extract to destroy grey-worm, the caterpillar of *Agrotis segetum*, L. The young plants must be copiously watered with this extract.

149. **Glue.**—Glue made from animal matter may be used to overcome the diseases of plants and animals.

Use.—*Peronospora viticola*, De By. (mildew of the vine).—Vesque asserts that solutions of glue cure the vine, but the treatment injures the development of the grape.

Schizoneura lanigera, Hausm. (woolly aphis).—Del Quercio declares that an excellent method of destroying this louse consists in coating the colonies with a mixture of $1\frac{1}{2}$ lb. of glue and 3 gallons of tar.

150. **Catechu or Cutch.**—This astringent substance, extracted from a species of Indian acacia, stops, according to Vesque, the development of the oidium.

151. **Rose Laurel.**—The infusions of this plant of the family of the Apocynaceæ are used in medicine against scab. According to Debray the rose laurel is macerated, in Algeria, for several days and the putrefied liquid used to destroy insects, chiefly the mole-cricket.

152. **Aloes.**—Aloes is the resinous juice, extracted from the leaves of several species of aloes. It is bitter and nauseous. It is used as a tonic, purgative, and drastic. In Tunis there is added to bouillie bordelaise, intended to kill the *Peronospora*, 1-1·3 lb. of aloes per 100 gallons of bouillie, so as to destroy altises simultaneously.

[THE END.]

GLOSSARY.

ABRAXAS GROSSULARIATA, Leach. *Phalena grossulariata*, L. Common names: English, the magpie moth; French, *Arlequin*, *Phalène*, or *Zérène du Groseillier*.—White and yellow caterpillar, with some black spots, which after the end of summer ravages gooseberry bushes as well as currant bushes, apricot-trees, and plum-trees.

ACARI or MITES. *Plant lice*.—The acari much resemble small minute spiders, differing, however, by their inarticulated body. They are usually oviparous or ovoviviparous. The larvæ differ essentially from the adults by their exterior conformation; they want principally a pair of legs; they reach the perfect state after several evolutions. Acari produce proliferations of the tissues: galls, felting, swellings, brown rust, changes in colour; leaves become yellow, red, or brown. The most injurious acari are the *Phytoptus* and the *Tetranychus*.

ACARUS OF THE GOOSEBERRY. *Briobia Ribis*.—Degeneration of the buds, leaves, and shoots; stunted and clustered.

ACARUS TELARIUS, L. *Red spider*.—See *Tetranychus telarius*; French, *Tetranyque tisserand*.

ACRIDIDES. *Locusts*.—Dangerous insects, invading Algeria, Tunis, and even the South of France. The best known are the Morocco locust, the pilgrim or travelling locust, the Italian locusts. See Locusts.

ACROSTALAGMUS ALBUS.—Fungus which covers with a white thick down farmyard dung fermented at too great a heat. It may become injurious to young cultivated plants.

ADOXUS VITIS. *Eumolphus vitis*, F. French common names: *Eumolphe*, *Gribouri*, *Ecrivain*, *Berdin*, *Diablotin*, *Vendangeur*, *Bête à café*.—Chrysomelide 5 millimetres in length, elytron (wing shell), maroon red, corselet and head, black. Insect as injurious to the aerial part of the vine as to its roots. The larvæ hatch about mid-June and pass the winter following in the subsoil where they feed on the vine roots. In spring they turn into grubs. The perfect insect hatches in the month of April or May. It first attacks the leaves, drawing straight and angular furrows; then the grapes, on which it makes grooves, which hinders the development of the grape and prevents it from ripening. The larva of the *Gribouri* may kill the stem, and the perfect insect seriously damage the crop.

AEGERIA TIPULIFORMIS. *Sphinx tipuliformis*, *Trochilium tipuliformis*.—The currant sphynx moth. See *Sesia apiformis*.

AGARICUS.—Mushroom.

AGRILUS SINUATUS, VIRIDIS or PIRI. French common names: *Agrile du Poirier*, *Bupreste Vert* (green burn-cow).—Insect 1 centimetre long, 2 millimetres wide. Its colour is copper green. Common insect, which attacks a large number of forest and fruit trees, chiefly oak, beeches, and pear-trees. The larvæ burrow in the wood and bark, then towards the second year of its evolution it pierces a hole in the wood, where it becomes a grub. The insect hatches at the end of June and lays its eggs in the bark of the tree. The latter suffer much from the invasion of the insect and produce no more fruit. Trees invaded by the *Agrilus* show cracks, often attributed to some other cause, and which always cause the death of the attacked branches. The young trees almost infallibly perish.

AGRIOTES. ELATERIDES.—French, Maréchal; English, wire-worms, click beetles, skipping beetles, skipjacks, spring beetles. Small coleoptera of 1 centimetre at the most, elongated and flattened; several species are injurious to grain and other crops. All these insects have the peculiar faculty of jumping when laid on their back. The larvæ alone injure crops. They have a thin, elongated, cylindrical body, like that of a worm; their colour is yellowish, shining; their maximum size is about 2 centimetres (¾ inch) long; their skin is scaly, very hard, and difficult to crush, hence their name, wire-worm, yellow-worm, under which name they are generally known. Their development is very long; it lasts five years. They feed at the expense of the roots and the tender parts of the plant, and as they are very voracious and polyphagous, they attack almost all cultivated plants, especially the radicles of germinating corn-seed. They sometimes cause considerable damage to young seedling wheat brairding on a light soil. During winter the larvæ bury themselves deeply in the soil and there remain benumbed, waiting for the renewal of vegetation. There are distinguished: (1) *Elater* or *Agriotes segetis*, injurious to cereals; (2) *Elater obscurus* (the dusky click beetle), injurious to carrots, cabbages, and salsify (the purple goat's beard or oyster plant); (3) *Elater lineatus*, the striped click beetle, injurious to cereals and hops; (4) *Elater Sputator*, *Taupin cracheur*, the spitting click beetle; (5) *Elater niger* (*Taupin velu*), the black click beetle.

AGROMYZA VIOLA.—The pany-fly.

AGROTIS (NOCTUA).—The different species injurious to crops have the same habits as *Agrotis segetum*, the common dart moth. The caterpillars are polyphagous, make their ravages at night and hibernate.

AGROTIS EXCLAMATIONIS. *Noctua Exclamationis.*—The hart and dart moth. Dark lilac caterpillar, three bright longitudinal lines, habits of grey-worm. The caterpillar gnaws the neck of roots and kitchen garden plants, turnips, asparagus; in spring it is particularly injurious to vines, the buds of which it gnaws.

AGROTIS SEGETUM, the common dart moth.—The butterflies appear in the middle of May. They lay in June, July, and August on all low plants, chiefly beets, at the level of the collar; two weeks after laying they are hatched. The grubs or grey-worm are typical: dark earthy green, two yellowish lines on each ring, four small black spots, length 5 centimetres (2 inches). They *make their depredations in the night*, and remain *close to the ground during the day;* they pass the winter in the ground where they bury themselves deeply like the white-worm; they awaken in the spring and recommence their attacks up to May. This is the time they are most to be dreaded. Winter grain crops, all young spring plantings, and even the buds of fruit trees suffer. They are especially injurious to beets, of which they devour first the young leaves of the collar then the collar and the roots (1855 invasion). They also injure potatoes and vines. They turn into chrysalis in the beginning of summer.

AGROTIS TRITICI. *Noctua of Wheat.*—See *Agrotis segetum.* Similar caterpillar also called *grey-worm.* It appears in July at the time the wheat plants are in ear and devours them the whole summer. It not only gnaws the collar of the stems but also attacks the seeds. It passes the winter in the soil and recommences its nocturnal depredations in the spring.

ALTERNARIA BRASSICÆ F. NIGRESCENS. *Roasting* (*Grilling*) *of the leaves of the melon.*—In the months of August and September when great heats are followed by rains the leaves of the melon are seen to dry up and brown. The fungus develops rapidly on the leaves with small yellow spots; as they get larger these spots end in big maroon spots which cover the whole leaf. The mycelium spreads into the parenchyma of the leaf and spreads its conidiophores on the faces of the latter.

ALTERNARIA SOLANI. *Macrosporium Solani* (potato leaf-curl).—Peculiar disease of the potato, characterized by the appearance of isolated spots of a brown colour brighter than those produced by the *Phytophthora infestans;* the leaves turn yellow at the same time. The tubers are not directly attacked but the exhaustion of the organs of the plant may reduce the crop. The organs of fructification are conidiophores which issue in tufts through the dried epidermis of the leaves. The detached spores germinate easily and readily spread the disease. The *Alternaria Solani* which causes damage more especially in Hungary is called *Macrosporium Solani* by the Americans.

ALTISES. *Halticinea*, *Earth fleas*, *Plant fleas.*—Small chrysomelines which are called earth fleas owing to their faculty of jumping. In spite of their small size, which does not exceed 3-6 millimetres in length, altises are dangerous enemies to crops because they appear in great numbers. They have several generations each year, the larvæ of which, as well as the perfect insects, ravage the leaves and the young buds. They are especially deadly to young crops.

ALTISE (kitchen garden). *Haltica oleracea*, *Altise of the Crucifers.*—Length 4-5 millimetres, oval shape, slightly bomb shape; its colour is a brilliant bluish-green. This altise attacks crucifers, cabbage, turnips, beets, the flowers and leaves of which it devours; it causes great havoc in gardens.

ALTISE OF THE VINE. *Haltica ampelophaga* (vine flea), *Pucerotte*, *Babotte.*—Small greenish-blue insect, 5 millimetres. It only requires six weeks to reach its full development. It appears on the first fine weather. The female lays its eggs at the end of April on the under surface of the leaf, the larvæ appear ten days afterwards; they burrow long grooves into the parenchyma; in ten days they reach full size, let themselves drop on the soil and there bury themselves to the depth of 2 inches; two weeks afterwards the perfect insects appear The altises of the vine cause great havoc especially in Algeria; they gnaw the back of the leaves and the vine shoots. The last generation passes the winter protected from the cold under the bark, in the fissures of the walls, etc., and issue from these refuges in the spring.

ALUCITE. *Sitotraga cerealella.*—Butterfly (tinea) of 6 millimetres in length, greyish-yellow, with long filiform antennæ. The Alucite has two generations in a season, the first a little before harvest, the second in autumn in the granaries. The female lays red eggs in the depression of the grain of wheat; before harvest the caterpillars penetrate into the interior of the grain stored in the granary where they finish their development; they gnaw the whole interior and only respect the epidermis. After having emptied the inside of the grain they there weave a cocoon and are converted into chrysalis. The temperature of the heap of wheat attacked increases 10° C. (180 F.°).

ANBURY, see PLASMODIOPHORA BRASSICÆ.

ANGUILLULIDÆ (eel-worms), see NEMATODES.

ANOBIUM. *Xylophagous coleoptera*, which cause ravages in our houses, and in food-warehouses. They bore round holes into the wood which seem bored with a gimlet. The vrillettis have a cylindrical body, and are of a dark brown colour.

ANOBIUM PANICUM, 2½ millimetres in length; it does not live solely in flour or in bread; it shows itself injurious to wood, to books, to dried fruits, to roots, to grain.

ANTHOMYIA OF THE CABBAGE. *Anthomyia*

Brassicæ (turnip-fly, cabbage-fly).—Length 7 millimetres, colour blackish-grey, eyes red. It flies in the month of May and lays its eggs in the collar of the cruciferæ. The maggot-like larvæ penetrate to the interior of the roots and the stems, there to hollow out burrows, and in October are there transformed into pupa to pass the winter.

ANTHOMYIA OF THE BULB OF THE ONION. *Onion-fly*. Three species: *Anthomyia antiqua*, *A. furcata*, *A. ceparum*.—Small flies of 7-8 millimetres, which lay their eggs end of April and May on the leaves of the onion. The small white larva descends along the leaves, penetrates into the onion and there hollows out burrows; it quits the onion to become a grub in the soil. The fly hatched in fifteen days gives birth to a second generation. They are great destroyers of onion beds.

ANTHONOME OF THE APPLE-TREE. *Apple blossom weevil*, *Anthonomus pomorum*.—Length, 4 millimetres; colour, blackish-brown, with short, compact hairs forming a down; rostrum arched. The adult insect lives the whole year at the expense of the apple leaves. In the spring the female pierces a hole in the floral envelopes and deposits an egg in each flower bud until finished laying thirty eggs at least. After an incubation of five to eight days the larva is hatched and attaches itself forthwith to the stamens and pistils of the flower, thus destroying the essential organs of the latter; the bud henceforth expands no more, it browns and dries up as if frostbitten. The French gardeners call these browned buds cloves.

ANTHONOME OF THE CHERRY-TREE. *Anthonomus druparum*.—Brown weevil of 5 millimetres which lays its eggs in the flower buds of cherry-trees.

ANTHONOME OF THE PEAR-TREE. *Anthonomus Pyri*.—Weevil very similar to anthonome of the apple-tree, but it lays its eggs in the floral buds of the pear-tree before and not during winter. Its larva is what gardeners call the *winter-worm*.

ANTHRACNOSIS OF THE HARICOT. *Colletotrichum Lindemuthianum*. — Fungus which attacks the leaves, stems, and pods of the haricot; it corrodes them profoundly, producing gnawed spots very like those of the anthracnosis of the vine. These spots, sinking deeper and deeper, may extend into the fruit as far as the endocarp of the pod, and reach the grains. On the surface of the spots there is formed a great number of pustules, produced by the cuticle, uplifted by a mass of conidia. The mycelium of this fungus does not push between the cells, like the greater number of parasitic fungi, but enters into the living cells, which soon brown and die. The spores, produced in the pustules, readily germinate in water, and the germinative tube, which issues immediately, pierces the epidermis to penetrate into the leaf, producing a spot after twenty-four hours. A warm temperature in moist weather favours the growth of the fungus and the extension of the disease.

ANTHRACNOSIS OF THE MELON. *Colletotrichum oligochætum* (Fr. *Nuile du Melon*).—The anthracnosis of the melon is observed on different cucurbitaceæ. When the very young plants are attacked, they are rapidly destroyed. Adult plants resist better and longer; but the fruits attacked, as well as the leaves, are entirely disorganized before reaching maturity. The disease is characterized by badly defined, yellowish spots which go deep down, especially in the fruit. The fructifications of the fungus appear on the dead tissues. They are small fleshy-rose masses containing conidia.

ANTHRACNOSIS OF THE VINE (grape rot). *Gloeosporium ampelophagum*, syn. *Sphaceloma ampelophaga*, Carbonnat.—The filaments of this fungus only live inside the cells and produce spots on all the herbaceous parts of the vine, each forming small ulcers gnawing the tissue as far as the soft parts of the liber. The branches are contorted and blackened as if they had been roasted on the fire.

APHIS (singular), APHIDES (plural). *Naked plant lice*.—In spite of their small size, the aphides do as much damage as large insects. They live in colonies, of which the individuals —always numerous—tightly packed the one against the other, reproduce themselves increasingly during fine summer weather and give birth to a progeny of thousands. Far from circulating from leaf to leaf, these apterous insects remain, on the contrary, fixed on the same spot; their rostrum, planted in the most delicate part of the plant, continually sucks the abundant juice which flows thereto. The result of this constant irritation of the cells of the plant is that it dies, or is in a diseased state, which shows itself by characteristic deformation of the organs. It will be seen that the leaves and the branches curl up, roll, swell, change colour, passing through white to yellow to red. Often exostoses and cankers are formed which greatly injure the physiological functions of the organs and render the plant diseased. Moreover, the plant lice secrete from their cornicles (small horns) a sort of honey-dew which they eject afar and which ends by covering the whole trees with a sticky, sugary layer preventing the respiration of the plant and attracting insects fond of this sugar. Fungi of the family of Capnodium, which live exclusively on this waste, develop there and finally cover the entire plant with their black mycelium, thus causing a disease known as *Fumagine* or smut of fruit trees. In the spring almost at the same time as the young buds the female aptera appear generally viviparous which are reproduced by parthenogenesis, that is to say, without the aid of the male. The young, always of the feminine sex, resemble them, and are capable of reproducing themselves in the same way in a few days. Parthenogenic reproduction of these individuals goes on during the whole of the fine summer weather, and the more rapidly the drier and warmer the weather. When the weather cools in the

autumn the last generation of these plant lice no longer produce viviparous individuals the same as themselves. They then lay eggs from which issue a short time afterwards either males or winged females which copulate. These females lay eggs in their turn. Amongst these eggs some give birth to apterous viviparous females which wait, hidden in the moss of the trunk, the heat of the spring to reproduce themselves and so recommence the cycle described. The others hibernate, hidden in the fissures of the bark and are not hatched until spring. Plant lice have not therefore like other insects slow and complicated metamorphoses which limit the number of annual generations, but although compelled to go through a special cycle the females are capable of reproducing themselves indefinitely into similar individuals without aid of the male and without slow evolution. That enables them to create in a season a legion of individuals endowed with the same destructive capacity and the sum of the work of which often produces terrible effects on the plant invaded. The number of species is unlimited, and there is no plant which does not possess one or more species which produce a characteristic degeneration of the organs attacked.

The spitting APHROPHORA. *Aphrophora Spumaria. Hemiptera*, of the grasshopper family, which lays its eggs in the end of autumn in the bark of plants. The larvæ, which hatch in the spring, suck the juice of plants and surround themselves so as to protect themselves with a viscous matter consisting of air-bells, resembling saliva so much as to be mistaken for it. Where they occur in very great numbers they may become injurious.

ARMILLARIA MELLEA (tree-root rot).—This fungus lives as a saprophyte and as a parasite; its mycelium penetrates into the living roots of very different species of trees and develops in the bark and in the exterior layers of wood; from the roots it gains the foot of the tree and there it produces yellowish-brown clusters of receptacles on the level of the ground. It attacks vines, apple-trees, mulberry-trees, fig-trees, on which it causes diseases which are confused with others under the general name of rot. [Commonest and most widely distributed of British toad-stools.]

ATHALIA SPINARUM (turnip saw-fly), see TENTHREDO.

ATHOUS.—Elaterides, the larvæ of which injure crops, see AGRIOTES.

ATHOUS HÆMORRHOIDALIS, injurious to the growth of flowers.

ATHOUS HIRTUS, injurious to beets.

ATHOUS NIGER, the black click beetle, injurious to potatoes.

ATOMARIA LINEARIS.—Coleoptera, 1 millimetre in length, with finely dotted elytra. The perfect insect appears at the moment of the germination of beet seed. It attacks the subterranean portion of the seedling and destroys it. If the plant is in braird the insect pierces small holes near the collar; the young beet blackens and dies. If it survives the root becomes forked and its sugar content is lowered. The insect afterwards attacks the leaves. The damage is done from May to July.

BLACK ROT OF THE GRAPE. *Guignardia Bidwelli.*—This disease, reported in France for the first time in 1885, is of American importation. It causes frightful ravages because it invades and destroys the grapes. It is due to the parasitism of a Sphæriaceæ which in succession shows *conidia* fruit and *asci* fruit. On the stalks of the leaves black rot shows itself by reddish, more or less circular, well-defined spots. These spots, small at first, become larger and finally run into large black spots consisting of conidia fruits. These same spots are formed on the branches on the cluster of grapes and on the grapes themselves. The black rot appears about mid-July when the grapes are as big as peas; it first forms a livid spot which enlarges quickly and invades the whole pulp; the grape then fades, its surface is depressed, forming large folds and it dries rapidly, assuming a violet-black colour. During this time there is formed on the black wrinkled surface of the grape thousands of small black globular projecting granulations which are the conidia fruits of the fungus called pycnides. It is not until winter that the peritheca, globular conceptacles filled with *asci*, are formed in the midst of the tissues of the dried grape. Up to the month of June of the following year these peritheca are found filled with well-developed *asci* on the grapes which have passed the winter either on the stock or on the soil. The ascospores germinate in a few hours after having been projected out of the *asci*. They put forth a germination tube which penetrates the epidermis of the leaves and there produce the spots described above. The organs of reproduction of black rot are of three kinds: the first and the second are conidia fruits which appear in summer on the leaves and the fruits and give out spores which spread the disease during the year; the third consists of peritheca, the spores of which transmit the disease to vines from one year to another. A knowledge of the successive phases of this disease alone enables it to be overcome effectively.

BOMBYCIDES.—Nocturnal moths, heavy and squat in shape, with a body abundantly covered with hair; the wings are at rest, sloped like a roof. The males have three pectinated antennæ; they are smaller and darker in colour than the females. The caterpillars almost always bristle with numerous long hairs; they spin cocoons to transform themselves into chrysalides.

BOMBYX ANTIQUA, ORGYA ANTIQUA (the common vapourer or brown tussock).—Sexual dimorphism; female grey, apterous; male reddish-brown, two white spots on the upper wings; the butterfly appears in June. The caterpillars are especially fond of pear-trees. Several generations up to October.

BOMBYX CHRYSORRHEA MOTH. *Liparis*

chrysorrhea (brown-tailed moth).—Butterfly, 30 millimetres (1·2 inch) from tip to tip. Wings white, as also the whole body, except the posterior extremity of the abdomen, which is brown. The female lays its eggs on the upper surface of the leaves, or on the branches of the trees, in agglomerated heaps covered with the brown hairs of the abdomen of the female, which gives them the appearance of minute sponges. The eggs hatch towards the end of summer; in autumn the caterpillars spin a common nest on a branch and there pass the winter dormant. In the spring they issue from this refuge, and commence their serious depradations by eating the young buds. They are brown with two red dorsal stripes and two white lateral spots. Injurious to fruit trees.

Bombyx dispar, Liparis dispar, Ocneria dispar (gipsy moth).—Great difference between the two sexes—the male has greyish-brown wings 3 centimetres, the female has yellowish-white wings 5 centimetres; the two are marked by zigzag lines. The female lays 500 eggs and covers them with a felt formed from the long brown hairs of its abdomen, the whole resembling a small sponge. The eggs pass the winter, the caterpillars hatch in the beginning of May; they are blackish with blue and red tubers; they live together, are polyphagous, and attach themselves, therefore, to a great number of trees—forest trees as well as fruit trees. In the United States they form a real plague. *Bombyx dispar* was introduced into America by a collector, where, deprived of its parasites and its natural enemies which decimate it in Europe, it has multiplied in such a disquieting fashion that a prize of 25,000 dollars was instituted to recompense whoever found an efficient remedy to cause its destruction.

Bombyx monaca, Liparis monaca (black arch moth).—Resembles the *Bombyx dispar*. The female lays its eggs at the end of July in small heaps of 20-50, forming plates which are never covered with hair. They are hidden in the cracks of the bark near the ground, they pass the winter. Hatching occurs at the end of April; the caterpillars remain together five to six days forming what are called mirrors; they gnaw pine needles. They cause great depredations in pine woods, they also attack the spruce, the oak, the beech, the apple-tree. Its invasions sometimes become a public danger.

Bombyx neustria (the lackey or barred tree lackey moth).—Butterfly of 30 millimetres from tip to tip; reddish, the upper wings are crossed by two whitish lines. It appears in July; the female lays regularly around a branch, and, by help of a fixing, coat 400 eggs which form a bracelet. These eggs pass the winter; the caterpillars live together in spun nests. When adult they are 4½ centimetres in length, a brown with a white dorsal stripe down the middle, and on each side red and blue longitudinal lines, hence its French name of livrée. Injurious to almost all trees.

Bombyx pini, Lasiocampa pini (pine-tree lappet moth).—Butterfly from 5-6 centimetres from tip to tip, maroon colour. On the upper wings a large dun-coloured middle band and a small spot in the form of a half moon. It shows itself in July. The female lays on the trunks of the *Pinus sylvestris* (Scots fir) in masses of 50 eggs which hatch about the middle of August. In the beginning of winter, in October or December, the caterpillars descend the trees to pass the winter dormant under the moss and the dead leaves. In the spring, in March or April, they re-ascend and attack the young shoots, frequently causing the death of the trees. Invasion in 1894 of the pine woods of the departments of Marne and Aube.

Bombyx processionea, Cnethocampa processionea.—Butterfly of 3 centimetres, greyish, uniform with dark sinuous bands on the wings; it flies in August and September, lays its eggs in packets of 200 on the bark of oaks and covers them with hair; the eggs pass the winter. The caterpillars pass all their existence together; they are bluish-grey with reddish tubers whence tufts of hair spring. The nests in which they shelter each night have only one orifice.

Bostrichus [Borers].—Small coleoptera belonging to the family of the Scolytides, distinguished by their cylindrical and bomb-shaped body, by their thick head drawn back into the thorax. They prefer to attack sickly trees, piercing the bark, then digging into its thickness a burrow in which the females lay their eggs; in six days the eggs are hatched; the larvæ dig winding burrows perpendicular to the chief burrow. The caterpillars are metamorphosed there. The insects perforate the bark and fly away.

Bostrichus typographicus.—The typographer bark beetle. It only attacks spruce trees; its presence is indicated by pale foliage of a dull tint, by a dark grey bark, by the fall of the needles at the least shake, and by a worm mould of havanna brown, after the asperities of the bark.

Botrytis cinerea (grey rot of the vine). *Vine Sclerotinia, Sclerotinia Fuckeliana*, De Bary.—In a humid and warm medium this fungus, generally saphrophytic, attaches itself to the leaves and the young buds of the vine; the young bunches of grapes may, likewise, be invaded at the time of flowering; but it is chiefly when the grapes are half-grown that the packed and compact grapes are attacked and destroyed by this fungus. The grapes attacked first assume a dirty tint, their surface tarnishes, they wither and become covered with a velvety grey which characterizes this disease. The favourable effect exercised by this mould on the quality of the white wines of Sauterne earned for it the name of *Pourriture noble* (noble rot), but this rot threatens to become a real plague since it invaded numerous vineyards and destroyed the crop. When the *Botrytis* develops only on ripe grapes it causes no damage, it is only then that it improves the quality of the wort. The green mould does

not attack the vine alone. On a number of plants on which at the outset the stems are seen to become brown, fade, and wither without apparent cause, the medulla contains *Sclerots* which produce conidiophores of Botrytis covering the damaged organs with an ashy, velvety grey. In gardens the lily, digitalis, balsam, the greater gentian, rose bush, the pelargonium, the begonia, the quarantine clove, hemp, may be mentioned.

Browning of the Vine. *Plasmodiophora.*—Damage to the leaves of the vine which occurs in autumn. Brown, irregular spots are seen to form on the upper surface of the leaves which extend in such a way as to form large sheets, sometimes completely covering the greater part of the surface of the leaf. This disease is attributed to a fungus, the *Plasmodiophora vitis.*

Browning of the Leaves of the Pear-Tree and Apple-Tree. *Phyllocoptes Schlechtendali.*—The acarus which produces this browning lives freely on the surface of the leaf; it neither produces galls nor felting. Its bites cause small isolated spots in the beginning, but which increase and brown afterwards.

Bruchus.—Small, squat-shaped weevils which attack the different leguminous seeds, peas, lentils, beans, tares, haricots. Each of these is attacked by a special species of *Bruchus*, but always in the same way. The perfect insect lays its eggs in the spring in the pods as they are being formed. The larvæ penetrate into the seed; there is generally only one larva per seed except in beans and haricots, where there may be two. The seed develops in the usual way, for the larva gnaws the albumen whilst respecting the grain. The larve reaches its development in the end of winter; it is transformed into a grub in the hollow seed, and in the month of May the perfect insect issues from it by boring through it. These seeds have lost a great part of their weight. If utilized for seed they have the drawback of springing up badly and yielding weak plants. The seeds attacked are easily known by their light weight, for they float in water, or by the small opening through which the insect has made its exit.

Bunt or Stinking Smut of Wheat. *Tilletia Caries.*—Fungus analogous to *Ustilago* (smut) which only attacks wheat grain. At harvest time the grains which do not, however, show any distinct outside indication, are filled with a brown powder which exhales a foetid odour. This dust consists of spores. The spores germinate in a moist medium and the germination filament pierces the stem of the wheat at the moment it starts to grow. See under Ustilago, p. 406.

Calandria granaria (wheat weevil).—Black coleoptera 3-4 millimetres long, the head is prolonged by a lengthy rostrum. The calandria passes the winter in the depressions of the floor; in the spring, in April, it gets into the heap of wheat, pierces a small hole in the groove of the grain and there lays a single egg. The same weevil thus pierces a large number of grains until it has ceased laying. The larva gnaws the interior of the grain; it only leaves the exterior pellicle which it uses as a cocoon to protect its grub. Hatching occurs in forty to fifty days. Breeding goes on all the fine summer weather; a single female may have a progeny of 60,000 insects in a season.

Capnodium, see Fumagine.

Capricorn (small): Cerambyx cerdo.—Coleoptera 2 centimetres long; attacks oak and fruit trees, chiefly cherry-trees and apple-trees in the same way as the preceding.

Capricorn: Cerambyx heros (the great capricorn).—Black coleoptera 5 centimetres long with two long antennæ which in the male are longer in the body. Corselet rugose. The larvæ which are very large attack the oak preferably; they take three years to become perfect insects and cause the death of the finest trees by the numerous and wide burrows which they bore in the trunk.

Cassida nebulosa.—Coleoptera (chrysomelide) 1 centimetre long, oval, with lateral expansions of the corselet and elytra forming a carapace recalling that of the tortoise. The perfect insects hibernate and issue from their retreats in the spring. The females lay their eggs on the upper surface of the leaves of the beet. The larvæ, of a pale green colour with two longitudinal white stripes, attain 1 centimetre in length. Segregated in great numbers on the under side of the leaf in the beginning of plant growth, they cause considerable retardation in the growth of the beets. There are as many as three generations a year.

Cassida viridis, or the artichoke tortoise beetle, is found in May and June on artichokes not more than $\frac{1}{16}$ of an inch in length. The antennæ are black, the dotted wing cases and other outer coverings green, the body black, beneath legs pale, thighs black, body of larva very flat.

Cecidomyæ.—Small gnat-like flies, 2-3 metres long, with long slim legs. The most injurious are:—

Cecidomya destructor (Hessian fly).—Blackish with red circles on the abdomen. It appears in April. The larvæ attack the base of the stem of wheat without penetrating into the interior; by persistent sucking they end in making small pits in the stem in which they lodge. Atrophy of the stem of the wheat results, and the latter soon breaks. There are three to four generations; the last generations are especially dangerous because the larvæ attack the plants and destroy them to a great extent.

Cemiostoma scitella (black spots of the leaf of the pear).—Microlepidoptera, the caterpillar of which is minute, which is to say that it gnaws burrows between the two epidermes of the leaves of the pear. These spots become black.

Cercospora apii (celery leaf blight).—The celery as well as other umbelliferæ, such as parsley and parsnip, are attacked by this fungus, especially during the hot

part of the year. The leaves are coloured with fawn-yellow spots, and when the fructifications appear they are covered with a brown dust. The spores soon germinate and invade the neighbouring and new leaves. Their germination tube penetrates into the parenchyma of the leaf, there ramifies and produces an alteration of the leaves which deprives the celery of all its market value.

CERCOSPORA BETICOLÆ (spots of the leaves of the beet).—This fungus is a very common parasite which lives on the leaves of the beet, but which causes no special damage; in wet seasons it propagates very rapidly, and the leaves are covered with grey spots bordered with brown from which the conidiophores issue in tufts, the conidia of which soon germinate.

CERCOSPORA RESEDA (mignonette disease).—This fungus forms pale spots on the leaves of mignonette, which afterwards are covered with brown tufts of conidiophores. It causes much damage in America.

CETONIÆ.—Coleoptera, some of which are gilded, 1-2 centimetres in length, the larvæ of which live in dung. The adult insect passes its life on flowers of which it devours the pistil and the stamens. They may become injurious to fruit trees, especially the *Cetonia stictica* and the velvety cetoin, *Cetonia hirtella*, on the vine. [*Cetonia aurata*, the green rose-chafer or golden rose beetle, is one of the largest and most beautiful beetles. The havoc they make in the Parisian rose gardens is said by C. McIntosh to be fearful compared to what we experience in Britain (TR.).]

CHEIMATOBIA BRUMATA (winter moth, Evesham moth).—Butterfly, only the male of which possesses wings whilst the female has only rudimentary wings and cannot fly. The female, hatched towards the end of October or the beginning of November, crawls on the tree with its large legs to lay its eggs in the crannies of the bark. The caterpillars hatch in the beginning of spring. They keep to the buds of fruit trees and gnaw the leaves and the flowers as they shoot out.

CHERRY-FLY.—This fly, 4 millimetres long, is brilliant black with a head and legs yellow and the wings crossed by four black bands; it appears at the end of May. The female lays a single egg on each cherry, preferably on the *bigarreau* and the geans. The larva penetrates into the interior and renders the cherry wormy. In the end of July it quits the cherries and lets itself fall on the ground where it is transformed into pupa, a sort of small barrel with a hardened skin. The insect issues in the following spring.

CICADELLÆ (grasshoppers). — The Cicadellæ are small jumping grasshoppers which are sometimes injurious to crops.

CICADELLA SEXNOTATA, JASSUS SEXNOTATUS (Cicadella of oats, Cicadella of cereals).—Yellow grasshopper, with brown spots, 3 millimetres long. They suck the leaves of the oats which turn yellow and wither. This small grasshopper causes by its numbers great havoc in young fields of corn, chiefly in oats and barley fields. These insects produce two generations in a year. Those of the second generation pass the winter in the shelter of the clods of earth. The grasshoppers only attack young plants, the leaves of which they suck. In the spring they choose winter wheat. As soon as the leaves become too hard they quit them to devastate the spring seedlings. The plants attacked are known at first by their red and then yellow tint; they soon perish.

CLADOSPORIUM CARPOPHILUM (plum scab).—It causes damage in America. It attacks the young fruits, producing spots, on which the skin is replaced by a sheet of cork underneath which hollows are formed; [attacks plums, cherries, almonds.—TR.].

CLADOSPORIUM CUCUMERINUM (cucumber rot).—This fungus produces on cucumbers black-greenish spots and the rapid rotting of the fruit.

CLADOSPORIUM FULVUM (tomato leaf rust).—The cladosporium causes great damage to tomatoes, especially in greenhouses. The leaves of the stocks attacked etiolate, turn yellow on badly defined portions of the limb, attain a length of 1 or more centimetres. On the parts of the leaf which are quite yellow above, a greyish olive coating is found underneath formed by the conidiophores of the fungi. The detached conidia spread the disease.

CLADOSPORIUM OLEAGINUM (spots of the leaves of the olive-tree).—The smooth mycelium glides under the superficial layer of cuticle and becomes encrusted in the upper cell walls of the epidermis; it does not penetrate into the parenchyma of the leaf; in this connexion it has a certain analogy with exoascus. At a given moment the mycelium pierces the cuticle, swells above the epidermis into a lump which produces spores at the summit. The spores attack the new leaves and there produce circular greyish or yellowish spots encircled with black.

CLEMATIS DISEASE, BLACK.—Disease due to parasitism of an anguillulide, "eel-worm," of the genus Heterodore which causes galls by its pricks on the roots of the clematis.

COCCIDES or COCHINEALS (plant lice, bark lice, scale insects, kermes).—These homoptera much resemble the "pucerons" by their manner of living. After hatching, these insects show great agility; then the apterous females fix themselves either on the young shoots, the leaves, or the trunks, sink their rostrum in the tissues and never move again. The body is ovoid, globular, and resembles a small excrescence of the bark. The female lays its eggs under this shell and dies, forming with its carapace a protecting shelter for its progeny. The plants attacked by these insects perish rapidly and are often invaded by "fumagine," or smut of fruit trees (Capnodium), the existence of which is intimately linked with the presence of these insects. Like the pucerons, the cochineals become dangerous by their number; they entirely cover the bark of the trees. The cochineals pass the winter dormant on the branches.

These are distinguished by the shape of the shield, the diaspines with the genera Aspidiotus and diaspis, the lecanium, the coccines. The most common are the following :—

Cochineal of the Apple (*Mussel scale*) (*Mytilaspis pomorum*), (? *Aspidiotus conchiliform*).—The shield resembles a small mussel shell. It attacks apple-trees.

Cochineal of the Peach (*Lecanium Persicæ*).—Very frequent on peaches in May and June.

Cochineal of the Pear-Tree (*Aspidiotus ostreaformis*), (the pear-tree oyster scale). —One of the most common of cochineals, distributed on the branches of fruit trees, especially apple-trees, where it forms small greyish spots.

Cochineal of the Pear-Tree (*Diaspis piricola*).—Analogue of the cochineal of the apple-tree ; the cochineal of the pear-tree has a red colour and not yellow like that of the apple-tree, a colour which is discerned by lifting the shield with the blade of a knife.

Cochineal of San José (San José louse), (*Aspidiotus perniciosus*). — It much resembles the preceding, and exercises its ravages, especially in America, on both fruit and forest trees.

Cochineal, White, of the Lemon-Tree and Orange-Tree (*Dactylopius citri*).—Its brown body is enveloped in a white waxy secretion ; the trees attacked look as if covered with cotton. The saccharine dejection, the honeydew, covers the leaves with a waxy secretion on which a Capnodium develops in abundance, creating the grave disease of the fumagine or the black of the olive. The trees invaded lose their leaves, perish, and the fructification cannot generally take place.

Cochineal, Red, of the Vine (*Coccus Vitus* or *Pulvinaria Vitus*).—The red cochineal of the vine has the appearance of a reddish-brown shell ; at the time of laying, it secrets a whitish cottony substance which forms above the body a sort of cushion very apparent. The males (coques) are 5 millimetres in length and are found along the branches. In the beginning of autumn the females fix themselves on the branches and assume the form of a shield.

Cochineal, White, of the Vine (*Dactylopius Vitus*).—The white cochineal of the vine, contrary to the red cochineal of the vine, never fixes itself and lays its eggs several times. The female is 4 millimetres long, the body shows distinct segmentation. These cochineals appear in the month of May. They lay their eggs in June on the under surface of the leaf. The adults pass the winter under the bark of the stems or in the soil. They cause the fumagine or smut of fruit trees.

COCKCHAFERS (white-worms). French, *Hannetons, Turcs, Mans.*—Lamellicorn coleoptera, the larvæ of which, the wire-worms, are polyphagous. The common cockchafer, MELOLONTHA VULGARIS. French, *Hanneton commun.* The female lays thirty to fifty eggs in the soil, at a depth of 3-7 centimetres. The larvæ hatch forty days after laying, their development lasts three to four years, according to circumstances. In November each year the white-worms sink into the soil to a depth varying from 50 centimetres to 1 metre, according to their size and the severity of the winter. They there remain dormant during winter ; five months afterwards they re-ascend near the surface and gnaw the roots of plants. They cause great damage in vineyards, meadows, beet-fields, and gardens. Having finished their growth in the month of August, the white-worms nymphose at a depth of 1 metre (40 inches) in the soil where they are surrounded by a shell. In November the perfect insect is given off by the nymph, but it remains in the soil to the spring, that is to say, until the beginning of the fourth year from the laying of the egg. It takes one or two months to reach the surface of the soil. White-worm years result from this triennial cycle of the evolution of the white-worm. The evolution lasts three years in the south of France, four years in the north of France. The larvæ are polyphagous, that is, gnaw indiscriminately the roots of all cultivated plants. Recently planted vines are frequently invaded, they cease to grow and their leaves turn yellow ; the proportion of destroyed grafts may reach 94 per cent.

COCKCHAFER (GRAIN). *Rhizotrogus solstitialis. Hanneton de la St. Jean.*—The larva is injurious to cereals, maize, trefoil.

COCKCHAFER, GREEN (PINE). *Melolontha fullo*, L. *Hanneton foulon.*—The larva of this big butterfly is injurious to pines.

COLASPIDEMA ATER (French names : *Colaspe, Negril, Babotte noire, Barbare*).—Black lustrous, 3 millimetres long. The colaspidema is a plague of the lucerne fields of the south of France. In the month of May the female lays about 400 eggs on the lucerne leaves where they hatch in twelve days. The larvæ are so voracious that a lucerne field may be ravaged in a few days. The perfect insect passes the winter underground, the larvæ is converted into a grub in the soil ; it hatches in the spring.

CONCHYLIS AMBIGNELLA (cochylis of the vine, the vine tortrix).—This small tortrix is about half the size of the pyralis of the vine, its length is 8 millimetres. The upper wings are yellowed, crossed by a wide brown band. The under wings are grey. Two generations annually. The caterpillars of the first generation invade in May the young vine shoots of the vine in flower, of which they eat all the parts ; the vine shoots which escape in the spring are afterwards attacked by the caterpillar of the second generation which invade the shoots at the time the grape ripens. When they have finished their work of destruction these grubs take refuge towards the months of September under the barks of the stocks or on the fissures of the props. There they assume the chrysalis form after spinning a silky cocoon.

COSSUS LIGNIPERDA (*Cossus gate bois*,

goat moth).—This bombyx lives three to five years as a grub which attacks indifferently weeping willows, poplars, elms, fruit trees, larches, and many other trees; it bores holes into these trees of the thickness of a finger which in multiplying form immense cavities on the trunk. The caterpillar is naked, bright red in colour; it gives off a decided odour of musk.

CRIOCERIS ASPARAGI (asparagus beetle). —Coleoptera (chrysomelide) of 6 millimetres in length, steel blue elytra, with four bright yellow spots.

CRIOCERIS DUODECIMPUNCTATUM.—Reddish-yellow coleoptera with six black points on each elytrum. These crioceres appear in the month of May. Their green viscous larvæ attack the asparagus, the leaves of which they gnaw. In June they bury themselves in the soil where they hibernate in a small shell.

CRIOCERIS MELANOPA (grain crioceris).—This small ($4\frac{1}{2}$ millimetres) coleoptera is bluish; it and also its larvæ gnaw the epidermis of herbs and cereals.

CURCULIONIDES (weevils). — Coleoptera characterized by a prolongation of the interior part of the head called the beak or rostrum; the form of the body is bomb-shaped, for the elytra always surround the lower part of the abdomen. The larvæ are polyphagous, they live in the interior of the vegetable tissues (fruits, roots, stems, buds, seeds).

Carrot Weevil (*Molytes Coronatus*).—Brilliant black with some yellowish spots, 12 millimetres long. In May the eggs are laid in the soil, the larvæ penetrate into the lower part of the carrot and ascend it by excavating burrows.

Ceutorhynchus sulcicollis (cabbage and turnip gall weevil).—Black, 3 millimetres long, appears in May, attacks all crucifers, cabbage, rape, colza, turnips, mustard, etc. The female lays its eggs in July in the roots or the lower part of the stem. The larvæ attack the bark. The irritation produces a hypertrophy of the parenchyma, generates nodular galls which grow until the larvæ perforate them, to turn into grubs in the soil. This insect is not dangerous except when it develops in very large numbers.

Curculio (*Otiorhynchus*) *Ligustici*. In French *Beccard* (female salmon). — This large brown weevil attacks fruit trees at night, also cultivated crops such as *Vetches* and *Sainfoin*. The female lays its eggs in the ground. The larvæ hatch in the middle of summer and gnaw the roots until the following spring, when they are metamorphosed to perfect insects about the end of May.

Curculio (*Otiorhynchus*) *sulcatus* (grooved weevil otiorhynchus, vine black). — This small weevil attacks the vine, the strawberry plant, and various ornamental plants. It is chiefly reported from Bordeaux, Languedoc, and Burgundy. It appears about the end of May in vineyards and browses on the buds and young shoots during the night. Its larvæ live underground at the expense of the roots.

Curculio (*Phytonomus*) *punctatus*.—The larvæ riddle the leaves of trefoil and lucerne.

Curculio (*Sitones*) *lineatus* (striped pea weevil).—Injures leguminosæ, especially peas and haricots. The perfect insect gnaws the young leaves in the spring, the larvæ gnaw the roots.

CURRANT LEAF SPOT, see GLŒSPORIUM RIBIS.

CURRANT SAW-FLY (*Nematus Ribis*).

CUSCUTA EPITHYMUM (dodder of trefoil and lucerne).—These plants which are deprived of roots and of chlorophyll are essentially parasites of other plants from which they draw nourishment by numerous suckers. The latter are formed at all points where the stem, enrolled as a tight spiral around the nurse plant, touches the surface of the latter. They extend rapidly in fields where the exhausted and dead plants form large spots. The rose-white flowers form seeds from which issue the young plants which crawl before fixing themselves and are even conveyed by the wind to a great distance.

DASYSCYPHA WILKOMMI (canker of the bark of the larch).—The canker of the bark of the larch often causes very great ravages. The first symptom is manifested by a yellow tint which the branches assume, the leaves fade and there is almost always a flow of [oleo] resin which is produced at a point where the bark is swollen and broken. On the dead and dried bark appear small white spots which, when the conditions favour their growth, develop into small cupules of pezize, white velvety outside and bright red on the upper surface. The mycelium of the fungus penetrates through the medullary rays and the resiniferous vessels.

DEMATOPHORA NECATRIX (white root rot). French names: *Blanc des racines*, *Mortaduse*, *Terre-bête*, *Grappe*, *Morille*, *Charme*, *Pourridie de la Vigne*.—This fungus lives at the expense of the roots of the vine, fruit-trees, mulberry-trees, fig-trees, maple-trees, oak-trees, and soon kills the tree. Its mycelium forms round the roots a white cotton-wool which afterwards assumes a greyish tint. It penetrates deeply into all the anatomical elements of the root, and it is only when the plant is dead that it produces fructifications. The white root rot is especially attributed to the *Sphæriaceæ Dematophora*, but this fungus is not the only one capable of producing this physiological condition of fruit trees. There are also *Armillaria mellea* (*q.v.*) and *Roesleria hypogea*, of which the mycelium invades the roots of trees in an analogous manner and causes the rot of the latter. A vine attacked by this fungus languishes rapidly and finally dies.

DOTHICHIZA POPULEA.—This fungus penetrates into the wood of the poplar through wounds and kills the parts invaded.

DRY ROT, see MERULIUS LACRYMANS.

EUCHLORA VITIS (*Anomala vitis*, green

cockchafer of the vine).—The female of this coleoptera lays about thirty eggs in the soil round the stem; the larvæ appear in the beginning of the month of August. They much resemble those of the cockchafer and do the same damage to the vines as the cockchafer (white-worm), (*Ver blanc*).

ENTOMOSCELIS ADONIDIS.—The perfect insect and its larvæ gnaw the leaves of radishes and cabbages in Canada.

EPILACHNA GLOBOSA. *Coccinella globosa.* —The larvæ of this coleoptera riddles the leaves of trefoil, lucerne, and potato.

ERINOSES. *Phytoptides* (gall mites).—The irritation caused by the bite of certain acari, the Phytoptes, cause alterations in the epidermal cells of the leaves which elongate under the form of hairs and form a felt, generally in the lower part of the leaves, which may be white, yellow, rose, or rust colour. This felt acts as shelter to the acari. When these attack the shoots and the buds, they are atrophied with formation of galls bristling with prickles. These diseases are widespread.

ERINOSIS OF APPLE-TREE AND PEAR-TREE. *Erinium Malinum et Pirinum.*—Felting of under part of leaves, passing from yellow and rose to rust colour.

ERINOSIS OF THE GOOSEBERRY. *Phytoptus Ribis.*—This acarus sucks gooseberry buds and leaves; the branches never develop and form packed bunches of leaves.

ERINOSIS OF THE VINE (Grise de la Vigne). *Phytoptus Vitis*, *Eriophyes Vitis.*—Leaves attacked by this Phytoptus show irregular-shaped swellings on the upper surface, and are coated on the under surface with down. White at first, the down becomes red, then brown, as it ages. This down, which cannot be detached by rubbing with the finger, sometimes covers the whole of the under surface of the leaves. The upper surface of the leaf always remains green. These Phytoptes pass the winter in the scales of the buds. This disease causes serious trouble, especially when it attacks the young seedlings which require complete development of their leaves to form their roots.

ERIOCAMPA ADUMBRATA. *Selandria atra* (the slug-worm or slimy caterpillar).—Saw-fly, of a brilliant black with a transversal brown band on the upper wings. It measures 5 millimetres in length and appears in the end of July. The female lays its eggs on the under surface of the leaves. The larvæ are first of a blackish-green, then of an amber-yellow and covered with a viscous substance; it vaguely resembles a small snail, hence the name slug-worm. They devour the parenchyma of the cherry-tree, the pear-tree, the plum-tree, and the apricot-tree. The leaves are reduced to the state of lace; growth suffers and the growth of the fruits is stopped. Nymphosis takes place in the soil.

ERIOPHYES PIRI. *Phytoptus Piri* (rust of the pear-tree, *Cloque du Poirier*).—This disease is produced by an acarus which dwells in the parenchyma of the leaf and circulates between the two epidermes. The irritation of its bites causes the formation of pustules, the red tint of which on the young leaves becomes brown and even black in a few weeks. On the lower surface of the leaf the epidermis is pierced with small holes which allow access of air and of insecticides.

ERYSIPHES. *Mildews.*—Mildews form on the leaves and on the young parts of the plants powderish, whitish spots. The mycelium of the mildew is always superficial, it crawls on the surface of the epidermis without penetrating into the interior of the organs. It sinks its suckers in the epidermis. Mildews produce not only conidia, but also peritheca which contain one or more asques; all these fungi under their conidia form have been designated under the generic term oidium; they then exhibit such a resemblance to each other that it is often impossible to distinguish the one from the other.

ERYSIPHE COMMUNIS (mildew of peas, trefoil, etc.).—Attacks peas, haricots, lentils, lupines, trefoils, and different crucifers. The disease extends over the two faces of the leaves. The plants attacked languish, and a crop may be entirely destroyed.

ERYSIPHE GRAMINIS (mildew of cereals).—It forms a persistent woolly coat, white at first then reddish; grows in isolated spots or on surfaces extending over the grain and the leaves of cereals, particularly wheat.

Mildew of the Ash Leaf and Hazel Leaf (*Phyllactinia suffulta*).—This mildew is found on the leaves of the hazel-tree, the ash, the hornbeam, the birch and the alder-tree. It covers the two faces of the leaf; the covering is spidery, white and transient.

Mildew of the Gooseberry (*Microsphæra grossulariæ*).—This mildew covers the two faces of the leaves with a greyish-white spidery covering.

Mildew of the Hop (*Sphærotheca Castagnei*).—This mildew, distributed over the most different plants, is particularly injurious to the hop. It attacks all the female inflorescences and destroys the crop. It very often attacks the inflorescences of *Spirea ulmaria*; it is very frequent on the cucurbitaceæ and in particular on melons and pumpkins, on the compositæ, plantains, pimpernels, veronicas. The spidery spots form on both sides of the leaves.

Mildew of the Rose and Peach (*Sphærotheca pannosa*).—This mildew is frequent in gardens where it covers the young shoots and buds of rose bushes.

EUDEMIS (tortrix of the grape). *Eudemis Botrana.*—This small butterfly has the same habits and causes the same damage as the cochylis, but it has three generations a year and thus attacks the inflorescence, the sour grapes (verjus), and the ripe grapes. The greenish caterpillar reaches 1 centimetre. The insect commits its ravages more especially in Southern France.

EXOASCUS DEFORMANS (leaf curl of the peach).—This disease is caused by the com-

plete deformation of the leaves, which thicken, curl, twist, and swell, assuming a pale yellow to rose tint. When the disease reaches a certain pitch, the young branches are also invaded and deformed. The mycelium of the fungus which causes this disease is very ramified; it spreads on the surface of the epidermis under the cuticle, forming a sort of perforated membrane. It applies itself wholly against the nourishing cells and extends itself in the space between the cells. By the action of the mycelium the cells of the epidermis and of the parenchyma multiply in an abnormal way. There is thus produced a homogeneous fleshy tissue deprived of chlorophyll which forms characteristic swellings. The mycelium gives out asci at a certain point which traverse the cuticle, and impart to the deformed leaves a velvety, whitish appearance. The spores developed in the interior of the asci are projected outside, through a transversal aperture. They are white sort of leavens, which placed in water multiply indefinitely by budding. The rust does not propagate itself from year to year by means of the spores, but chiefly by the mycelium. The latter, which is perennial, hibernates in the buds whence it penetrates into the young leaves. The periodical appearance of leaf curl causes great damage to the tree and finally kills it. Leaf curl therefore causes great damage. The bites of plant lice sometimes cause an analogous deformation of the leaves.

Exoascus pruni (pocket or bladder plums).—This fungus is in all points comparable with the *Exoascus deformans* which produces the leaf curl of the peach, but instead of deforming the leaves it lodges in the pistils of the flowers which assume under its influence an extraordinary development. The pistil is converted into a sort of hollow elongated pocket. The mycelium is hardy and passes the winter under the young branches whence it penetrates in the spring into the young pistils of the flowers.

Fidonia pinaria (phalena of the pine).—Dark brown butterfly; the upper wings of the female are striped with yellow bands, 4 centimetres from tip to tip, the male 3 centimetres. The caterpillars gnaw pine needles which they generally cut through the middle and let one-half fall to the ground. The ravages last from August to October. The caterpillar is green with white and yellow longitudinal lines. It reaches 3 centimetres in length. It descends the length of the trunk in winter to metamorphose itself in the moss of the soil.

Finger and Toe, see Anbury and Plasmodiophora Brassicæ.

Fumagine. *Capnodium* (smut of fruit trees).—Fumagine is the term applied to the black coating which appears on certain plants infested by plant lice or cochineals (scale insects). This coating is formed by the black mycelium of a fungus which lives solely on the saccharine liquid, the honeydew, which the insects project on the leaves without ever penetrating the epidermis to extract food. The damages caused by this fungus are serious because they injure the regular functions of the leaf, and they, moreover, soil the fruit which they render unfit for food. The cochineal and consequently the fumagine are very injurious to trees especially in orchards.

Fusarium nov. sp. (flax disease).—The exhaustion of the soil in flax cultivation so common in America is due, according to the researches of Bolley, to the presence of a fungus which, in attacking flax plants, weakens them and eventually causes them to perish; growth is stopped, the shoots fade and finally dry up.

Fusicladium cerasi (black spots of the cherry).—This fungus, very analogous to the foregoing, attacks cherries on which it produces small black-green velvety spots. The cherries attacked late in the season ripen without their taste being altered. However, when the fungus invades the young cherry of the size of a pea, the latter dries up, browns, and withers before ripening.

Fusicladium pirinum (pear scab, pear holes). *Fusicladium dentriticum* (apple scab, holes of the apple).—These two fungi are very analogous, and do the same damage, the one on the pear-tree, the other on the apple-tree. The *Fusicladium pirinum* attacks the leaves, branches, and fruits of the pear-tree. Numerous dark spots appear on the leaves which become pulverulent and of a black olive-green. On the young shoots the fungus also forms black spots and speckled places which become more or less deep holes on the branches, kill their extremities and dry up the buds. The fruits covered with black spots are soon deformed and holed as they grow, thus losing all their value. Certain varieties, like the *Doyenné d'hiver*, are particularly sought after by this fungus. Black conidiophora are to be seen on examining the leaves as well as the branches and fruits; they are formed on the mycelium which extends into the superficial tissues of the organs attacked; numerous spores fall from their summit. The conidia germinate very easily in a few hours when they fall into a drop of water; their germinative tube glides some time on the surface of the fruit, there ramifies, and finally pierces the epidermis where it chiefly grows without fixing itself deeply into the neighbouring tissue. In winter spermagonia are formed on the branches which transmit the disease from one year to another. Moist seasons greatly favour this disease. *Fusicladium dentriticum* produces black velvety olive-green-covered spots on the leaves of the apple-tree, on the fruits brown or dark spots, sometimes isolated, sometimes confluent. The skin of the fruit is killed on the space occupied by these spots and ends in being replaced by a layer of cork. When the apple is invaded early the skin may be killed over a large surface. The latter not being able to keep up with the growth of the flesh of the fruit, it follows that the apple grows irregularly and that it forms hollows more or less deep under the diseased

parts. When the apple is attacked late the damage is confined to spots which, without preventing ripening, greatly injure its appearance and depreciate its market value.

Galeruca of the Elm. *Galeruca calmariensis.*—The larva of this insect is as injurious as the perfect insect. The eggs laid on the leaves hatch in May: the larvæ, very voracious, reduce the leaves to skeletons up to the time they nymphose, say up to August, when they descend the trunk to bury themselves in the soil. The parenchyma of the leaves being gnawed the veins alone persist, and the leaves, reduced to a skeleton, soon fall. The tree then towards the end of summer presents quite a winter appearance. If their ravages occur two years in succession they may kill the finest trees on a promenade.

Gall Mites, see Erinosis.

Gangrene of the Stem of the Potato (disease caused by the *Bacillus caulivorus* which especially attacks plants from cut potato seed).—The diseased stem is greatly altered in its lower part. The disease extends from the surface of the soil to the leaves, the infected plants soon die.

Glœosporium frutigenum (bitter rot of the apple). — This disease, prevalent in America and in England, is characterized by brown spots which are produced on the green apples and are covered by black dots, the pycnides of the fungus. The spores do not appear to attack the apples except at the wounded spots.

Glœosporium Juglandis (disease of the leaves of the walnut).—Fungus, which produces on the leaves of the walnut large reddish-brown or greyish spots on which black pycnides are observed.

Glœosporium nervisequum (plane (*platanus*) leaf scorch).—This fungus attacks the veins of the leaves a little after their full growth. Towards the middle of May great withered spots form on the leaves with veins. These leaves soon fall.

Glœosporium ribis (currant leaf spot).—The disease produces withered spots on the leaves and causes them to fall in midsummer. A number of small spots are produced on the upper surface of the leaves attacked. These spots are produced by the organs of fructification of the fungus and are still covered by the brown epidermis of the leaf, which bursts at a certain moment to let the spores escape.

Glœosporium venetum (raspberry spot).—This fungus produces grey spots bordered with red on the stem and leaves of the raspberry. They so damage the plants that the fruits do not ripen.

Grapholitha Wœberiana (tinea of stone fruit trees); Tortrix (Carpocapsa) Weberiana.—The caterpillar of this microlepidoptera perforates the bark of plum-trees, peach-trees, apricot-trees, and almond-trees, penetrates into the alburnum and there undergoes metamorphosis. It kills the bark by the wounds it produces; it causes canker and a flow of gum. It prefers the peach and the plum.

Gryllotalpa vulgaris (mole cricket).—The mole cricket lives almost entirely on insects and their larvæ. To search for this underground food it cuts all roots that hinder it. It passes the winter in the earth at depths varying with the temperature and moisture, then in the spring it re-ascends to within a few centimetres of the surface, where it excavates numerous runs, which end in a vertical hole, which gives access to the burrow properly so called. The invasions of the mole cricket are not spontaneous; it takes about twelve years for the number of these insects to increase so far as to render culture impossible. The existence of each insect is three years; the female lays 200 eggs, but in spite of this great fecundity multiplication is comparatively slow. Short of food the mole crickets eat each other.

Gum. *Gummosis* (bacillary of the vine). French terms: *Roncet*, *Gelivure*, *Aubernage*, *Moragement*, *Courtnoué*, *Dartrose*, *Mal nero.*—This disease is due to the parasitism of a bacteria. The damage of the tissues consists in a gummy degeneration of the wood. It is believed that the disease enters through the pruning wounds, for this disease gains ground more especially from top to bottom. At the same time as the disease propagates itself towards the roots the bark becomes hollow on the shoots, and big fissures are formed on that year's branches. The diseased stems languish, wither; the branches become stunted, the leaves fall prematurely, and numerous shoots spring from the foot of the stocks. The vines eventually die.

Gummosis of Stone Fruit Trees (cherry leaf spot).—The fungus *Coryneum Beyerinckii* is regarded as the chief cause of the gum of stone fruit trees, known under the name of spot of stone fruit trees.

Gymnosporangium Sabinæ (pear leaf cluster cups).—This uredina is heteroic; it has its spermogonia and aecidium forms on the pear-tree, its uredo and teleuto forms on the *Juniper Sabinus*, *oxycedar* of Virginia. When the relation which exists between these two forms of the same fungus was unknown, one was called *Roestelia cancellata*, the other *Gymnosporangium Sabinæ et fuscum.* The disease appears on the pear-tree in the spring. It forms big yellow spots on the surface of the leaves, spots which are besprinkled with purple-red spots, the spermogonia. At the end of the year these spots form white excrescences on the lower surface of the leaves, a sort of irregular galls, which contain aecidio spores. When these spots are numerous the growth of the pear is greatly weakened, but the parasite becomes especially dangerous to the crop when it attacks the fruits. It then forms irregular swellings. The fruits so hypertrophied are stopped in growth and are absolutely valueless. The aecidium form lives in the spring-time on the juniper. The destruction of junipers causes the disease to disappear.

HADENA BRASSICA (cabbage moth). *Mamestra Brassicæ.*—The caterpillars of several noctua ravage cauliflowers and ordinary cabbages, especially when they are hearted. They form numerous holes and penetrate to the core.

HALTICA UHELERI. *Punaises des Capsides.*—This bug sucks the leaves of the potato.

HETERODERA RADICICOLA. — Nematode, which lives as a parasite on the roots of very different plants, but contrary to the nematode of the beet produces galls on the roots. These galls shelter the worm during the whole of its development. They sometimes reach the size of a pea, and generally have only a very slightly unfavourable influence on the plant as long as the worm remains. As soon as the worm quits it the galls rot and cause the roots to rot. On annual plants the presence of these nodes is not to be feared, as the rotting of the gall coincides with the harvesting of the plant, but on hardy plants and trees their effect makes itself felt by lowering the crop from these plants. It is thus that this eel-worm produces swellings and atrophes on vines, resembling those produced by the phylloxera. This parasite prefers moist soil. In Italy and Portugal the destruction of several vineyards by the accumulation of this nematode is reported.

HETERODERA SCHACHTII (nematode of the beet).—This microscopic worm is met with on the roots of different plants, such as the cabbage, spinage, colza, but it commits its depredations especially on the beet. The larvæ of the nematodes prick the radicles of the beets with the dart with which they are furnished, and fix themselves by the head in the cellular tissue. These insects increase very rapidly, for each female can lay 400 eggs and produce three generations a year; their vitality is thus very great. Aimé Girard showed that they may resist an interval of three years fallow. It is also recognized that they may traverse the digestive tube of animals fed on beets without their vitality suffering. They may thus be propagated by farmyard dung, and it is therefore indispensable to disinfect it by carbon disulphide. The disease is recognized by its exterior character. In summer the old leaves of the beet turn yellow and die. The centre leaves only grow slowly. The root thus remains small, and, according to Hollrung's analyses, it contains little sugar. The presence of the nematodes may thus appreciably diminish the value of the crop.

HYDNUM SCHIEDERMAYRI.—This fungus is an apple-tree parasite which rots the wood. It bores the trunk, forming great holes of rot, whence issue in autumn irregularly shaped, yellow, fleshy receptacles, which may reach 5 centimetres (2 inches) in diameter and 10 centimetres (4 inches) thick. They smell of anise.

HYLESINES.—These are Scolytides, which are distinguished from the bostrichus by their elongated legs and their corselet narrow in front. The larvæ and the perfect insects dig burrows in the trunks of trees.

HYLESINUS PINIPERDA (the pine-destroying beetle). *Jardinier de la Foret.*—Black insect, 4 millimetres, which appears in July and pierces the bark at the base of plants of a few years' growth; it there penetrates as far as the medulla and ascends the young tree, emptying it as far as the terminal bud, through which it issues. At the approach of winter it takes refuge in the moss. The female lays its eggs in the spring in a single sinuous burrow made in the liber; the larvæ afterwards excavate lateral burrows there. There are sometimes two generations yearly. It attacks the *Pinus sylvestris* (the Scots pine), *Pinus maritimus* (the maritime pine), and *Pinus laricio* (the aleppo pine).

HYLOBIUS ABIETIS (the spruce pine weevil).—Brown, red-haired insect, 1 centimetre long. It appears in pine and spruce forests in May. The females lay their eggs at the foot of old trunks. The larvæ pierce burrows in the bark. The adults are more injurious than the larvæ because they gnaw the terminal buds of the pine.

HYLOTOMA ROSÆ.—Rose saw-fly of 8 millimetres; black with red abdomen. The green larvæ gnaw the leaves of the rose-trees, only leaving the veins.

HYPOMYCES PERNICIOSUS. *Mycogone perniciosa* (mole disease of the mushroom).—Mushrooms attacked by the mole grow in an irregular manner, swell, puff up, and become deformed to such a pitch as to be nothing but an irregular-shaped mass. This mass is covered in places by white spots and easily rots.

HYPONOMEUTE OF THE APPLE-TREE (tinea of the apple-tree); HYPONOMEUTA MALINELLA (small ermine moth).—Small butterfly, the upper wings of which are white and covered with black spots. The butterfly lays its eggs in August on the branches of the apple-tree. The larvæ hatch in September and pass the winter in a tissue of coarse silk, from which they only issue in May. They then go on to the buds and the young shoots, envelop them with a silky fabric which acts as a shelter, and thus live together to the detriment of the parenchyma of the leaves. As soon as the leaves of one branch are destroyed the caterpillars pass to another. A few nests of these caterpillars are capable of devastating a whole tree, which in summer would appear rusted, as by a late frost. The caterpillars assume the chrysalis form at the end of June in small white elongated cocoons, collected in mass in a protective fabric.

LACHNOSTERNA ARCUATA (red cockchafer), the larva of which gnaws the roots of vines and strawberry plants in America.

LEPTINOTARSA DECEMLINEATA (the Colorado beetle).—Deep yellow coleoptera, closely allied to the chrysomelides; 1 centimetre in length with five black longitudinal lines on each elytrum. This insect does great damage to potato fields in America. It gnaws the leaves as larva as well as in the perfect state,

and produces abortion of the tubers. Very energetic methods are adopted to prevent it being imported into France [and Great Britain]. It showed itself in Europe as far back as 1877, but the sources of infection have been destroyed each time that it has been observed.

LETHRUS CEPHALOTES (big-headed lethrus).—The lethrus is a sort of *bousier* (cow-dung insect?) which is injurious to vines. It is 2 centimetres long, its body is globular and black. The lethrus is chiefly met with in Russia and Austria-Hungary. It is nocturnal, and digs its burrow near the stocks. Before dawn it issues from its hiding-place to ascend the vines and cut the young vine shoots at their base, and carry these into its burrows.

LEUCANIA UNIPUNCTATA.—The caterpillars of this tortrix penetrate inside grass stems and thus greatly injure meadows.

LOPHODERMIUM PINASTRI (pine leaf cast).—Fall of the leaves of the pine. This parasite commits great depredations, especially in nurseries of two to three years old. As early as the autumn of the first year the seedlings are invaded and the leaves are spotted with brown and become red. Spermogonia are formed; as these grow the leaves wither up completely. The black perithecæ, larger receptacles than the spermogonia, are not formed until the following year on the same spots. After prolonged wet weather the pyrothecæ open through a slit and show the asci filled with a bundle of spores. These spores spread the disease. Special weather conditions—a mild winter and a wet summer—greatly favour the growth of this parasite. It may then devastate a nursery. The young plants attacked by the rouge may be regarded as lost, but if part of their leaves remain intact they may rehabilitate themselves A plant attacked by the rouge is too weak to be transplanted.

LOPHYRUS PINI (pine saw-fly).—1 centimetre long; head black, corselet yellow with black spots, abdomen yellow. The females lay their eggs inside the pine needles; the green larvæ gnaw the needles and weave against the leaves small cocoons of brownish silk. The second generation appears in July, the third in October. This generation nymphoses and lays its eggs in the moss at the foot of the tree.

LOPUS SULCATUS. *Grisette de la Vigne*.—This bug of 7 millimetres with yellow bands and points, appears at end of May and attacks the flower buds of the vine, sinking its sucker into them. The female lays its eggs in the cracks of the bark and the crevices of the vine props, preferably in the medulla of the cut vine shoots. The larvæ hatch in the following spring and spread first on grass and on mustard, and then on the vine.

LUCANUS CERVUS (stag-beetle).—Large coleoptera, 3-4 centimetres long, furnished with very highly developed deer-horn-shaped mandibles. The larvæ, the development of which takes four to five years, bore holes in the trunks of the oak, birch, and beech.

LYDA CAMPESTRIS (pine saw-fly).—Black and yellow fly, 2 centimetres long, yellow wings, appears in June, and does the same damage to pines as the *L. pratensis* does to meadow plants. The larva buries itself in the moss at the foot of the stem in the month of August, there to pass the winter.

LYDA ERYTHROCEPHALA.—The larva attacks pine needles and hides itself at the foot of the tree in June.

LYDA PRATENSIS (meadow saw-fly).—Yellow and black fly, 13 millimetres in length. It flies in May. The larvæ, 2 centimetres, are brown with a yellow head. They gnaw the leaves and descend in the month of August into the soil to pass the winter in a sort of lodge.

LYGUS PRATENSIS (meadow bug).—This bug is sometimes very injurious to apple-tree and pear-tree buds.

MERULIUS LACRYMANS (dry rot).—This fungus, allied to the Polypora, is not a parasite of the wood of our trees but is the most dreadful destroyer of building timber. In Europe it is widespread and does great damage. It chiefly attacks resinous woods and produces the dry rot of pine timber and pitch-pine. It sometimes also attacks the oak; its development is favoured by moisture. When the presence of this parasite is reported in a town it is necessary to take great precaution to avoid contamination of construction timber. If one spore is laid on the surface of one of these timbers it will suffice to contaminate the whole house.

MILDEW, see ERYSIPHES.

MOLE CRICKET, see GRYLLOTALPA VULGARIS.

MONILIA FRUTIGENA (brown rot of stone fruits).—This fungus causes great ravages, especially in America, in peach nurseries. The disease is characterized by the browning of the fruit, the flesh of which shrivels up, becomes as hard as horn, mummifies, and finally only forms a hard layer round the stone. The mycelium which lives in the interior of the pulp fructifies the same or the following year. Perennial during winter in the withered fruit, it revives in the spring under the influence of the heat, and produces grey tufts consisting of wreaths of spores which spread the disease. In Europe it is especially a wound parasite. Fruits, whether stone or pip fruits, may be invaded by it, especially if wounded.

MULBERRY DISEASE, BACTERIAN.—Boyer and Lamber discovered that this disease is due to the *Bacterium Mori*. It shows itself on the outside by brown-black spots on the lower face of the leaves and the branches; on the latter the spots are elongated and are eroded in the form of more or less deep cankers. The disease begins on the top of the branches, which appear carbonized over a certain length and bent in the form of a cross. The leaves soon wither, rolling up towards the midrib.

NECTRIA CINNABARINA (necrosis of wood; coral spot disease).—This fungus, which generally lives as a saprophyte on dead

wood, appears also as a parasite and corrodes the wood. It attacks the horse chestnut, the maple, the ailantus. Its mycelium not only extends into the bark but into the wood itself; it is a parasite of the ligneous body like the polyporæ, which live at the expense of the starch. The corroded wood no longer serves for the passage of the sap and the tree dies eventually. In the autumn this disease is easily recognized, for there is seen to appear, across the dead bark, cushions of stroma which become covered with conidia on which the peritheca are produced. This visible form is termed *Tubercularia vulgaris*.

Nectria ditissima (canker of the apple-tree, the pear-tree, and the beech).—This fungus is the immediate cause of some cankers which gnaw the branches of the apple-tree and the pear-tree. It is one of the most formidable diseases of fruit trees. Cankers are generally bordered with small coral red points which are the peritheca of the fungus; they form real wounds in the bark which do not cicatrize and which always extend and sink deeper and deeper. On the edges of the wound the still healthy tissue forms swellings, but these are rapidly destroyed by the fungus. This corrosion hinders the circulation of the sap, the trees languish, become covered with dead wood, and produce no more fruit. The first phenomena explains itself on the outside by a point of bark which becomes depressed, forms concentric fissures and causes the bark to tear, which falls in strips. The mycelium is not only found in the bark but in the ligneous body and in the interior of the vessels, and the cells of the ligneous parenchyma. It multiplies in the midst of the disorganized tissues. The woolly aphis prepares the way of access to this fungus.

Nematodes Injurious to Cultivated Plants.—These are small worms of a filiform aspect, a smooth tegument, which live in the interior of plant tissue, causing characteristic deformations of the organs attacked.

Nematus ventricosus, Nematus ribis (gooseberry saw-fly).—The larvæ of these saw-flies attack different species of gooseberries, entirely deprive these shrubs of their foliage, and thus prevent the development of the fruit. During May the larva which is adult descends into the ground to turn into a grub. After three weeks the insect hatches and forms a new generation.

Noctua: Agrotis, Mamestra, Plusia.—The noctua are moths, they are not so heavy as the bombycides. The wings are characteristic; the upper, darker than the lower, have two spots. The caterpillars are glabrous, greyish; they do not spin a cocoon, they pass into chrysalides in the soil.

Noctua gamma, Plusia gamma.—Greyish-brown moth of 4 centimetres with a silver spot which represents the Greek letter Gamma on each of its upper wings. The moth flies in the daytime, the green caterpillars have an appearance which recalls the citigrade spider. They attack leaves of the most different nature: cabbage, beet, potato, colza, hemp, flax, maize, peas, beans; there may be two or three generations a year.

Noctua of the Lettuce. *Polia dysodea*.—Noctua, the wings of which are of a greyish-white with more or less dark-coloured bands and spots. The caterpillar of pale green with three dorsal, longitudinal brown stripes, gnaws the leaves and the seed of lettuce.

Noctua of the Pine. *Trachea piniperda*.—Butterfly, $1\frac{1}{2}$ centimetres long, head, thorax, and upper wings, red, with yellowish-white spots and lines on the latter. The abdomen and the lower wings greyish-brown. The female lays in April on the needles of the *Pinus sylvestris* (Scots pine). The caterpillars attack the young shoots; they are green with white and orange longitudinal bands; they reach 3 centimetres in length in July; they turn into chrysalis in the moss at the foot of the tree and there pass the winter.

Oidium of the Vine. *Uncinula americana*, *Oidium Tuckeri*.—The mycelium of this fungus lives on the surface of the plant and draws its nourishment from the cells of the epidermis by numerous suckers. The organs attacked are rapidly altered, the extremities of the young shoots wither, the leaves shrivel up and die, but the effect is still more deadly on the grapes, which crack and rot. The oidium, which is propagated by its conidia during the whole growing period of the vine, may entirely destroy a crop. The worst attacked plants may, however, again become vigorous if the disease is arrested in time. The oidium may be recognized by the white or greyish efflorescences on the parts attacked. The oidium first appeared about fifty years ago. The disease appeared to attack certain varieties of vines with a black grape. *La Folle Blanche* of Charentes and Armagnac was not attacked until five years later. Owing to the oidium the wine crop of France fell from an annual production of 50,000,000 hectolitres (1,100,000,000 gallons) to 22,662,000 hectolitres (498,564,000 gallons) in 1853 to 10,824,000 hectolitres (238,128,000 gallons) in 1854. This production was the smallest of last century, for even in the acute period of the phylloxera it was not reduced below 25,000,000 hectolitres (550,000,000 gallons).

Opatrum sabulosum.—This insect of the family of tenebrionides appears in May. It attacks the buds of grafts from American stocks, especially when they are earthed up. The larvæ live two years in the soil.

Ophiobolus graminis (disease of the lower part of the stem of wheat).—Laid wheat is due to the invasion of the winter nodes nearest the soil by a fungus which, in damaging the stalk at the level of the soil, is often the cause of the laying of the straw of cereal crops. The mycelium develops in the interior and the exterior of the tissue.

Orobanche minor (orobanche of clover, broom rape).—The orobanches are parasitic phanerogams of the roots. They live exclusively at the expense of the plant on which they graft themselves for they are-

deprived of chlorophyll. The seeds only germinate in contact with the roots of the nurse plants. They plant themselves there, and their root which is a mere sucker penetrates, whilst it ramifies as far as the vascular bundles. These root suckers are perennial if the orobanche is fixed on a perennial plant, and the multiplication of this parasitic plant may take place without the intervention of its seed. This is especially the case with the orobanche of clover.

ORYCTES NASICORNIS. *Rhinoceros.*—The larva of this large insect resembles an enormous white-worm. Generally it lives almost exclusively on decomposing vegetable matter, in melon beds, and in dung in gardens. Perroncito regards it as being the cause of damages done in Italy to the roots of vines.

PEAR LEAF CLUSTER CUPS, see GYMNOSPORANGIUM SABINÆ.

PENTATOMA OLERACEÆ (cabbage bug).—Green bug with red marks on the female, white marks on the male, 6 millimetres long.

PENTATOMA ORNATA (the decorated bug).—Piebald bug, red and black, 1 centimetre long. The female lays its eggs on the lower surface of the leaves, they are placed so as to form bands. The larvæ, like the adults, suck the juice of the leaves.

PENTATOMIDES (bugs).—Several species of pentatomides, known vulgarly as *bugs*, live at the expense of the crucifers. Owing to their large number they may cause great damage in cabbage fields by sucking their juice.

PENTODON PUNCTATUS.—This coleoptera, injurious to vines, much resembles the bousier. Its larva, which when full grown is twice the size of the white-worm, lives in the soil to the detriment of the new plantations of grafted American vines, for which it has a marked preference, of which it gnaws the young wood for two to three years.

PERITELUS GRISEUS.—This little weevil nightly attacks in hundreds the buds of the vine and fruit trees. It preferably hides during the day in the buds or in the soil at the foot of the vine.

PERONOSPORA (mildew and white rust).—Fungi of which the mycelium lives in the interior of the tissues and which produce on the surface of the attacked organs whitish tufts resembling blights. They are chiefly distinguished by the fact that their mycelium lives in the interior of the tissues whilst the blights crawl on the surface of the organs attacked.

PERONOSPORA ARBORESCENS (mildew of the poppy).—It attacks the leaves and the inflorescences and may cause great damage. The conidiophora are on the lower part of the organs attacked and form a white, then yellow velvety coating. This *Peronospora* attacks different species of poppies.

PERONOSPORA GANGLIFORMIS (lettuce mildew).—The lettuce mildew does not attack lettuces alone but different other composite plants. It often attacks artichokes, chicories, and cinerarias. There are annually grown by market gardeners (French) about 2,000,000 lettuces, of which the *Peronospora gangliformis* sometimes destroys a third. It appears chiefly on the salads forced in beds to sell as early vegetables. The leaves are covered, especially below, with white efflorescences formed by the conidiophora. The conidia germinate very easily, without, however, forming zoospores like the *Peronospora viticola*, by issuing directly a germinative tube which penetrates the leaf and creates in the cells a new mycelium. The leaves invaded commence by yellowing, they then dry or rot. In the atmosphere, continually moist and warm, which reigns under the frames, it will be seen that nothing is opposed to the rapid progress of this disease, and that the ravages may become considerable. The organs of propagation from one year to another are the oospores which are formed in the débris of the dead leaves. It is therefore necessary never to throw them with the dung which will form the mould of the following crop, but to destroy all the diseased plants. To avoid invasion, it is well to select new soil into which to transplant the lettuce.

PERONOSPORA SCHACHTII (mildew of the beet).—Beet crops are sometimes ravaged by beet mildew. The parasitic fungus which produced this disease preferably attacks the young leaves, thus becoming in many cases one of the causes of the rot of the heart of the beet. Amongst beets, the leaves of which have been attacked, the amount of sugar contained in the roots is always considerably diminished. Like that of the mildew of the vine the mycelium of *Peronospora Schachtii* crawls between the cells of the plant and pushes the grey lilac conidiophora through the stomata, especially to the lower surface of the leaves. The detached conidia germinate freely in water and their germination tube pierces the epidermis of the leaf to instal itself there. Dormant spores (oospores) are formed in autumn in the attacked leaves. This disease is, therefore, propagated by the leaves of diseased beets from one year to another. When the disease exists in a field the leaves must be destroyed and not carried to the stable nor the dunghill. They are buried on the spot. Rotations greatly prevent the spread of this disease by oospores.

PERONOSPORA SCHLEIDENI (mildew of the onion).—This mildew causes great damage to onion crops. In wet weather it may assume such an extension that the whole of the plant is invaded and all the onions perish rapidly. Like all *Peronospora* the mycelium lives in the interior of the leaves, especially the young ones, and discharges conidiophora through the stomata. The conidia which are detached therefrom are the organs of dissemination during summer, and the oospores formed in the dead leaves transmit the disease from year to year. The stocks attacked by this parasite have leaves with yellow zones which wither; the plants become yellow and finally die.

PERONOSPORA TRIFOLIORUM (mildew of clover).—This fungus attacks clover, lucerne, and a great many leguminous plants. When

the disease declares itself in a wet year in a lucerne field, the crop may be regarded as lost. Living in the interior of the leaf the mycelium emits conidiophora which cover these with a white or grey lilac flock surface; the leaves attacked are discoloured, wither and fall.

PERONOSPORA VICIÆ (mildew of the pea and the vetch).—This mildew, which attacks different species of peas and beans, is distinguished by a dense lilac flock surface formed on the leaves. The organs of propagation and dissemination are the same as those of *Peronospora*.

PERONOSPORA VITICOLA (mildew of the vine).—This fungus has great analogy with the *Phytophthora*. It prefers to grow on the leaves of the vine, but it also invades the young branches, the flowers, and the grapes. (Brown rot, grey rot, juicy rot.) The leaves begin to grow yellow on the attacked vines, then the spots are intensified and the vines assume a reddish-brown colour. This fungus lives between the cells and the parenchyma and on the under surface of the leaf emits conidiophora from which the conidia or summer spores are detached. These ripen in a night and germinate as soon as they fall on a leaf rendered moist by the dew or by the rain; they produce mobile zoospores. After a sojourn of half an hour in a drop of water, they fix themselves, emit a germinative tube which pierces the epidermis and penetrates into the interior of the leaf. Late in the season, winter spores are formed in the leaves which remain active and live in the withered leaves. In the spring the spores spread the disease. Mildew appears early in May and June. The disease is often arrested after the first spring invasion by the dry heat of summer, but only by a heat of 20° C. (68° F.). If the air be moist the disease spreads more energetically and makes rapid progress. *Peronospora* does not rest like the *Phytophthora* in the perennial state in the plant during winter; it forms in autumn oospores in the attacked organs which hatch in the spring and again start the disease. The organs of dissemination are especially the summer spores or conidia which are formed by thousands on the tufts of conidiophora on the lower surface of the leaves and during the whole summer. These conidia, fortunately, are not endowed with the same vitality as the oospores. Cold and dryness destroy them easily. Moisture, on the contrary, keeps them alive, but however great it may be, this moisture does not suffice to make them germinate. It not only requires the direct contact of water with this spore to cause germination, but a surrounding temperature between 17° and 30° (62·6°-86° F.). About 17° C. the conidia take about two days to hatch, from 25° to 30° half an hour suffices. The fine drops of dew in warm weather are especially favourable to the hatching of the disease. Looking to the great number of conidia formed, it will be understood why, when the conditions are favourable to their germination, the invasion is so sudden and so general and why in summer in dry weather mildew causes no damages.

PHALENIDES or GEOMETRIDES.—Butterflies with a rugose body and large wings, generally nocturnal. The caterpillars are called geometers or *arpenteuses*, owing to their method of walking in the form of an inverse U.

PHOMA TABIFICA (beet and mangel rot).—The disease of the heart of the beet is in certain cases the result of the invasion of a fungus. It reaches its height in September. In August leaves appear on the beet which droop as if faded and finally wither more or less completely. That is due to damage to the petiole of the leaf, which shows over a great part of its length a whitish withered spot surrounded by a brown aureole. The disorganization is propagated, following the bundles, as far as the heart of the beet and kills the whole of the young nascent leaves.

PHYLLOXERA OF THE VINE. *Phylloxera vastatrix* (aerial and subterranean).—The adult female lays a single egg on the wood of the aerial part of the vine called a winter egg. The young apterous phylloxera which issues from it either immediately gains the roots or the leaves of the vine, on which it produces a characteristic gall doing little injury to the plant. This aerial form or gallicole of the phylloxera is rarely found on French vines, but it is very widely spread on American vines, the roots of which are not generally invaded by the insect. The aerial form of the phylloxera does not belong to the indispensable cycle of the very curious evolution of this insect. The young phylloxeras which descend to the roots prefer to fix on the radicles to introduce their dart there and to remain fixed at the same spot, continually sucking the juice of the plant. By this constant irritation, first the bark swells, then hypertrophy of the cambium, hence the formation of tumefactions. After the death of the phylloxera these nodosities rot and cause the decomposition of the root. The large number of phylloxeras fixed on all the roots rapidly cause atrophy of the radicular system, and by that fact alone the vine languishes even in the first year and may die in the second. The phylloxeras of the roots are always females or rather parthenogenetic subjects which breed without sexual intercourse. Each individual lays daily 30-40 eggs or gemmations, the eggs of which hatch in eight days. Twenty days after their birth they are reproduced in the same way. With 6-8 parthenogenetic generations yearly an individual may reproduce thirty million descendants. Amongst the last gemmation of summer there are eggs which give birth to a new winged form which abandons the roots, ascends the plants, and disperses itself in the vineyard. This form is also parthenogenetic; it lays on the aerial part of the plant four eggs which hatch new sexual forms, male and female. These individuals are deprived of digestive organs and do not therefore take nourishment. Coupling oc-

curs between these two new forms and the female lays in autumn the single egg referred to above. It will thus be seen with what rapidity a hot-bed of phylloxera may extend and propagate itself in the neighbourhood. In the south of France the phylloxera first appeared about 1863. In 1865 a real invasion was reported near Avignon and at Floriac, near Bordeaux, which spread rapidly. It was not until 1868 that Planchon discovered the cause of these ravages, the *Phylloxera vastatrix*. This aphis was already known in America under its *gallicole* form since 1854 and in Great Britain where it appeared in the greenhouses as far back as 1863. In 1877 it invaded the department of Loir and Cher, where in the first year it destroyed 288,000 hectares of vines (720,000 acres); in 1884, 429,000 hectares (1,072,500 acres) shared the same fate, and in 1888 half of all the French vineyards were invaded or destroyed by this formidable parasite. In that way the crop diminished considerably; in Vaucluse, for example, it fell in 1876 from 400,000-500,000 hectolitres (8,800,000-11,000,000 gallons) to 49,000 hectolitres (1,078,000 gallons). It was only from the beginning of that time, that is in 1874 and 1876, that the phylloxera reached Germany and Switzerland. Energetic measures were taken to prevent the propagation of this insect, and the importation of vines from contaminated countries was prohibited.

Pieris Brassicæ. *Pieris Rape* (large white cabbage butterfly, small white cabbage butterfly).—They are white, diurnal, well-known butterflies. The former female lays its eggs in June on the surface of the cabbage leaves where these masses form plates of a white colour; the female of the second lays its separate eggs in packets. The caterpillars of the former are greenish-grey with three longitudinal lines and reach 5 centimetres in length; that of the second are green with three yellow longitudinal stripes. There are two generations a year. The caterpillars attack all cruciferæ; they are dangerous because they appear in very large numbers and gnaw the leaves, leaving only the veins.

Pissodes notatus (small pine weevil).—A smaller-sized weevil than the large pine weevil, 8 millimetres long, brownish-red with elytra striped with two whitish cross bands. It attacks pine plantations of four to eight years which it devours in the adult as well as in the larva state. The perfect insect, which appears in May, gnaws the terminal shoots and buds, especially those of the *Pinus sylvestris* or of the Weymouth pine. The female lays its eggs in the bark of the high parts of the tree. The larvæ bore sinuous holes between the wood and the bark; they turn into grubs in these holes.

Plasmodiophora Brassicæ (Anbury, finger and toe).—This disease is characterized by excrescences on the roots. It causes stoppage of growth and kills the plant. This disease may attack all varieties of cabbage, as well as beets, turnips, and radishes. The fungus which accompanies this disease belongs to the family of Myxomycetes, fungus consisting of a protoplasmic mass, the plasmodium, which changes incessantly in shape and which moves after the style of the lower organisms, the amœba.

Polypora.—These receptacle fungi form projecting lamellæ either fleshy or ligneous in the form of a bracket or a horse-shoe attached laterally by their base in the interior of which their mycelium is spread. Polypores attack fruit trees. They cause white rot especially of the wood of the oak. They rapidly damage the wood of the trees which they invade. The infection occurs especially in the spots where there are fissures which have been produced by frost, where there are sections of cut branches, in short all wounds are open roads to the penetration of these dangerous fungi.

Polyporus igniarius (false tinder fungus).—As widespread as *P. sulphureus*, it preferably attacks very old oaks and there causes white rot, but it also shows itself on the beech, the poplar, the hornbeam, the willow, and on fruit trees. Infection is propagated by passing from the alburnum and the liber to the heart-wood. The latter is rapidly consumed, dissolved, and reduced into a whitish friable mass which is separated from healthy wood by a brown border. The receptacles are ligneous caps, rust-brown and greyish colour; flocked on the upper surface they rise one above the other.

Polyporus sulphureus (heart wood rot).—This widespread fungus especially attacks the oak, the walnut, the pear-tree, and the poplar. Where it fructifies yellow sulphurous hoods appear rising one above another.

Polystigma rubrum (plum-leaf blister).—In the spring the leaves attacked by this fungus are covered on the two faces by red spots corresponding to small receptacles of spores formed on the mycelium which develops in the middle of the parenchyma. By developing between the cells of the tissues, this mycelium separates the cells from one another and disorganizes the tissues that cause the exhaustion and weakening of the tree. The dead leaves contain peritheca, which produce spores in February or March. These spores placed on a leaf of the plum-tree germinate in a few hours, and their germination tube perforates the epidermis to penetrate into the parenchyma of the leaf.

Potato Disease. *Phytophthora infestans*.—The fungus which is the cause of this disease attacks the leaves, the stems, and the tubers of the potato. The disease appears first on the leaves and the stems where it shows as brown spots which end by entirely covering them. In wet weather it spreads rapidly and may then destroy the plant. The disease develops likewise in the tubers where it shows itself by brown spots and by an alteration of the adjacent tissue. The infection of the tubers is not always induced by the mycelium of the aerial part of the plant, the latter only penetrating rarely down the stems into the tubers. The tubers

are infected by the conidia which are detached from the leaves and which are entrained on the roots by rain water. The mycelium develops in the interior of the organs attacked and gives off conidiophora on the exterior of those on the under surface of the leaves. The conidia which readily become detached are summer spores which may develop immediately, either by emitting a germinative tube or in forming mobile zoospores which fix themselves and soon produce the disease. The *Phytophthora* may pass the winter in the tubers. The *Phytophthora* is not propagated by means of oospores from one year to another like *Peronospora*. It passes the winter in a hardy manner in the interior of the diseased tubers. In spring it penetrates the nascent shoots of these tubers. Such shoots remain sickly if they are much infested by the mycelium and sometimes have not the strength to pierce the soil. On the somewhat vigorous shoots the mycelium forms conidiophora early, the conidia of which spread this dreadful disease over the whole field.

Potato Scab.—This is due to the growth of an aerobic bacteria in the living tissues of the circumference of the tubers. Under the irritating influence of their development the cells grow in an abnormal fashion below the point of attack and form a thick crust which greatly depreciates the market value of the potato.

Psila rosæ (carrot-fly).—The larva of this small fly, of not more than 4-5 millimetres, is black with yellow head and legs. It dwells in the carrot and there bores holes which cause the root to rot. The larvæ turn into grubs in the soil; there are two generations a year.

Psylla.—Hemiptera, distinguished from the plant lice by the arrangement of their legs which enables them to jump; besides they do not present asexual and sexual generations, alternating the one with the other; they are all sexual.

Psylla of the Pear. *Psylla Piri.*—This *Psylla* as well as *Psylla piricola*, which are only to be distinguished from one another by their different colour, cause great ravages on pears. The *Psylla* appears towards the end of May after having passed the adult state in the anfractuosities of the bark. After coupling, the female lays its eggs on the leaves and young branches, which then appear as if dusted with yellow. The apterous larvæ which hatch in a few days pierce and suck the parenchyma of the leaves and the young branches; the latter especially bend and perish.

Pyralides.—The *Pyralides* are microlepidoptera of larger size than the tortricides and tinea; their wings are of a triangular form, the antennæ long and pectinated. The grubs though small cause considerable damage.

Pyralis of the Apple-tree. *Carpocapsa pomonella* (apple-worm, codlin moth).—Moth of ½-1 centimetre long, ashy-grey wings striped crosswise with small dark sinuous lines, with bronze reflex lustre and marked at the extremity with a brown spot encircled by a gilded yellow line. After fecundation the female lays its eggs one per fruit on the epidermis of the new-formed fruit and on the surrounding leaves. In about eight days the newly hatched small caterpillar penetrates into the interior of the apple. The fruit then becomes wormy. There are two swarms a year. The caterpillar of the second swarm issues from the fruit when the latter is ripe and passes the winter for the great part under the bark of the fruit tree where it spins a cocoon. In the spring it changes into chrysalis.

Pyralis of the Plum. *Carpocapsa funebrana* (wormy plums, plum worms).—Small butterfly, 7 millimetres long, blackish with some spots and lines of a greyish-blue. In July the female lays its eggs on the still green plum. As soon as hatched the caterpillars penetrate into the fruit and remain there until maturity. Same habits as the preceding.

Pyralis of the Vine.—Tortrix, 1 centimetre long, of a more or less gilt yellow. The butterfly flies in the end of June; the female lays 100-200 eggs on the upper surface of the leaves forming a sort of greenish-yellow plate. The eggs hatch in the end of August. The caterpillars hibernate between the fissures of the props and under the bark in a small case of white silk which they spin. In the following May they quit their cocoons and gnaw the young buds; they agglomerate the small nascent leaves with silk thread thus preventing the buds from expanding; moreover they encircle the small grapes with a silky envelope inside which they shelter. The caterpillars reach 3 centimetres long, are green with very small whitish tubers; the head as well as the first ring are black.

Rot. *Rhizoctinia.*—Parasitic fungi which develop on plant roots, penetrate into their interior, and kill them. Their vegetative system is highly developed and enables them to pass in the soil from one root to another. Sclerotes, sorts of tubers, enable them to live a latent life when outside conditions are unfavourable to their development.

Rot of the Heart of the Beet. *Pleospora putrefaciens.*—The rot of the heart of the beet may be produced by several fungi. That which is the most ordinary cause is the *Peronospora Schachtii*, which directly attacks the small leaves of the heart and covers them with a lilac flocked surface. The *Sphœrella tabifica* causes indirectly the rot of the heart in passing from the petioles of the largest leaves to the heart itself. In both cases the heart leaves which are dead are covered with a greenish-black coating.

Rot or Moist Gangrene of the Potato.—This disease is a complete disorganization of the plant which is attributed to the action of the Bacillus Amylobacter (Kramer) and according to American specialists to the action of Oospora Scabies (Thaxt).

ROT — WHITE, PALE, LIVID. *Coniothyrium Diplodiella.*—This fungus is a parasite of the grape, which may in certain cases do considerable damage, as occurred in 1886 in La Vendee, in 1887 in Le Gard, and in L'Herault in Upper Italy and Switzerland. The *Coniothyrium* do not attack the grapes in the same way as the *Guignardia.* Whilst the latter attacks isolated grapes in an irregular manner leaving the stalk unaltered, the former invades the stalk of the grape shoot and the sheath of the grapes. The latter change colour, become livid brown, and soften, and then wither, turning an earthy colour. On the skin of the dead grapes there form small globular conceptacles which give them a shagreen appearance. Often it is the peduncle alone which is disorganized which causes the almost ripe grapes to fall. The mycelium develops in the parenchyma of the grape stalks attacked and spreads thence into the skin of the grapes where it forms, when that is withered, picynides like black rot. These picynides are up to now the only organs of reproduction known; their spores appear to preserve their germinative faculty all the winter and even up to the following summer, and can thus transmit the disease from one year to another. These spores do not appear to attack the leaves, as the disease is unknown on the grapes. Generally the germination tube of the spores penetrates into the stalks of the grapes by wounds produced by large hail-stones or by insects. This fungus appears to be more particularly a wound parasite which thus renders it especially dangerous after violent storms or an invasion of cochylis.

RUST, LINEAR OR COMMON. *Puccinia graminis.*—This rust attacks wheat, barley, oats, a host of common grasses, such as meadow grass, couch grass, dactyla, agrostis, cauche?, flouve?, foxtails, brizes?, fleoles?, festuca, etc. It is the most dangerous rust of cereals. It particularly attacks the leaves, their sheaths, and the stalks (straw). The uredo form appears at the end of the month of June. They are elongated pustules which let an orange-coloured powder escape. At the latter end of the season these spores form black pustules, puccinia, the black rust of farmers, in which the teleutospores are developed. These spores emit in the following spring a promycelium of which the sporidia only germinate. On the barberry, they produce æcidium, the spores of which infect cereals and produce the uredo form.

RUST OF BEET. *Uromyces Betæ.*—This rust is autoic, which means that the whole cycle of its evolution is gone through on the same plant. All the forms of fructification may therefore be formed on the beet. It attacks the beet in summer, and may, when it assumes a great development, damage the leaves, and cause a perceptible decrease in crop. The uredospores form small, very numerous ovoid or round pustules, which pierce the epidermis and let a yellowish-brown powder escape.

RUST OF CEREALS. *Puccinia.*—At least three different species of rust are to be seen on grain crops. They are uredinæ which are termed heteroic because during their cycle of evolution they must live on nurse plants of different orders. Uredinæ of this genus have, therefore, multiple methods of fructification which generally succeed each other in the course of the year in a fixed order. In the early spring the spermagones and the æcidium appear; in the course of summer the uredo; finally in autumn the teleutospores. The uredo or red rust form is the form of dissemination of the fungus during the germination of the cereal, the black rust or puccinia assures the transmission of the disease from year to year. The mycelium of these fungi grows exclusively in the interior of the organs of the plant attacked. The spores are generally formed under the epidermis of the nurse plant through rupture of which it is spread outside. The mycelium is most often localized and only occupies a limited point of the tissues which it destroys. The orange spots seen on plants each correspond to a special hotbed of infection. At these spots the mycelium forms felted masses which destroy the living tissues. The spores which form under the epidermis become detached as soon as ripe, and may germinate immediately if they fall in a drop of water in warm weather. The germinating tube, crawling on the surface of a leaf, for example, penetrates into a stomata and extends into the tissue, reproducing in eight days an analogous spot to that from which it escaped. A rust spot on a cereal may thus contaminate the whole field in a few weeks. At the backend of the season orange rust is no longer formed, but black rust or puccinia, a pustule of a black colour. The spores formed in the puccinia differ from the uredospores in the fact that they do not become detached on ripening from the end of their support and do not germinate until after several months' rest in the following spring. These spores are termed teleutospores. The teleutospores do not produce a germinative tube capable of penetrating by a stomata into the nurse plant and of developing there. The teleutospores give rise to a promycelium, the growth of which is limited and on which spores form the sporidia. As they develop they may pierce the epidermis of the nurse plant which is always a different species. The mycelium has a form of fructification which differs from that of the uredos and the puccinia; the pustules appear in the spring and are of two sorts, the æcidium, forming on the lower surface of the leaves, and the spermagones, forming on the upper surface of the leaves. These two forms spring from the same mycelium; spores are formed in these two receptacles. The spores formed in the æcidium are capable of reproducing the rust disease on a new support which is always a cereal. Those formed in the spermagones are called spermatia. Their rôle is not yet finally established.

RUST OF COMPOSITÆ. *Puccinia Tanaceti*, *Puccinia compositarum*.—This rust, injurious to compositæ, especially to *Artemisia dracunculus*, *Absinthium et vulgare*, *Tanacetum vulgare*, to the growth of chrysanthemums, is characterized by small round, brown and black cushions which spot the leaves.

RUST OF GOOSEBERRIES. *Puccinia Ribis*. —The rust causes great damage by attacking gooseberry leaves and fruit.

RUST OF THE LEAVES OF THE MULBERRY. *Cylindrosporium Mori*.—The leaves of the mulberry have, from the first of spring, brown, pale, irregular spots, limited by the veins. On these spots pustules are to be seen, in which conidia form, by which this fungus multiplies all the year round. The peritheca appear on the leaves, which fall at the end of the season. The disease does not cause great damage; but it renders the leaves unfit for feeding silk-worms.

RUST OF OATS. *Puccinia Coronata*.—This rust is peculiar to oats. It has, like the preceding rusts, the uredo and puccinia forms on oats, but on the contrary the æcidium form on different plants of the Rhamnaceæ, particularly buck-thorn and black alder.

The rust of cereals often cause a considerable decreased yield when the temperature is warm and the air humid; the great number of pustules exhaust the plant and prevent the normal formation of grains, living at the expense of the substances accumulated for that purpose. Garola found that 1000 grains of wheat from the rusted plant only weighed 22·2 grammes, whilst the same number of grains from healthy plants weighed 42·8-65·5 grammes. According to Gregoire the decreased yield is 8 per cent to 23 per cent for straw, and 21 per cent to 47 per cent for grain.

RUST, SPOTTED. *Puccinia Rubigo vera*. —The uredo pustules formed on the leaves and the stems of cereals are more oval than those of the linear species. It is *the* rust of *wheat*, although it also attacks *rye* and *barley*. On wheat it develops abundantly in the spikelets, on the glumes where it can cause great damage by stopping the growth of the grain. Spotted rust does not fructify like linear rust but as uredo and puccinia on the cereal, and produces æcidium on the plants of the family of Boraginæ: vipers' bugloss, bugloss, officinal borage, comfrey, lycopods of the fields, officinal cynoglossum (hound's tongue).

RUST OF SPRUCE NEEDLES. *Chrysomyxa Abies*.—The young needles attacked in the course of summer, from mid-June to mid-July, turn yellow where the fungus is localized. In autumn there are formed on these yellow parts projecting elongated golden-yellow cushions, consisting of a mass of teleutospores. In the spring the epidermis splits above these cushions, the spores issue, give off a promycelium charged with sporidia and reproduce the dust on the new shoots.

RUST OF STONE-FRUIT TREES. *Puccinia Pruni*.—This rust attacks the plum-tree, apricot-tree, almond-tree, and peach-tree. It is recognized by its cinnamon-brown tufts consisting of uredospores on the under surface of the leaves and the rapid alteration of the latter. The trees attacked lose their leaves prematurely.

RUST (VESICULAR) OF THE BARK OF THE PINE. *Peridermium Pini*, *Pine Cluster Cups*.—In May bladders or whitish membranous sacs, which split to let the æcidium spores which they contain, and which form an orange dust, escape, are seen to appear on the pines, chiefly at the foot of the stem of the young plants, or on the branches of adult plants. The mycelium extends between the bark and the liber, and sinks into the wood through the medullary rays. The mycelium is perennial and forms new receptacles each year until the branch is exhausted and dead. Under the influence of this fungus, the starch in the cells is converted into turpentine, which flows through the holes in the dead bark, and resinifies on the surface of the diseased parts. On the young pines the mycelium soon invades the whole stem, and kills the tree, thus producing great ravages in young plantations. The adult trees resist longer, but, owing to the great damage to the bark, and the cambium layer, they languish, gradually lose their branches, and top and finally die. This uredineæ is heteroic; its uredo and teleuto forms are found, according to Klebahn, on the swallow-wort (*Vincetoxicum officinale*) under the name of *Cronartium asclepiadeum* (Fries).

RUST (VESICULAR) OF PINE NEEDLES. *Peridermium oblongisporium*.—This rust is similar to the preceding, but it is localized in the needles. It develops æcides in such large numbers that the trees become perfectly yellow, but the damages caused to the trees are less perceptible than those caused by the preceding fungus.

RUST, WHITE, OF CRUCIFERÆ. *Cystopus Candidus*. RUST, WHITE, OF COMPOSITÆ. *Cystopus Cubicus*. — The hyphæ of the mycelium of these diseases glide between the cells of the nurse plant and there sink their suckers. The conidiophora form white pustules which are found indifferently on the surface of the leaves, stems, flowers, and fruit, for the fungus invades all the plant and causes it to undergo very curious deformations. These diseases can only be transmitted when their spores succeed in introducing themselves through the stomata into the cotyledons of the young plant. It is then that they invade the plant during its growth and infect all the organs. The first of these diseases is injurious to water-cress, to turnips, and to cabbages. The second to viper-grass, and to salsifis.

RUSTS. *Uredinæ*. — The uredinæ are parasitic fungi the mycelium of which grows exclusively in the interior of the body of green plants. Their spores are generally formed under the epidermis of the nurse plant, whence it spreads outwards through the tearing of the epidermis which occurs. It is from the orange-brown colour of their

spores that the uredinæ are termed *rusts.* Generally the mycelium of the uredinæ is localized and only occupies a limited point of the tissue of the nurse plant. It does not traverse it throughout to fructify in a determined point like the mycelium of bunt and the greater number of *Ustilago.* Where the germinative tube of a spore enters the tissue of a plant, it ramifies and produces its fructifications. The leaves charged with rust spots are soon exhausted, they turn yellow and die prematurely. The evolution of, rust varies much, a description of the important rusts seems therefore desirable.

SAPERDA CARCHARIAS (shagreen saperda).—Among the longicorn coleoptera injurious to wood, the saperda is one of the most common. It is 27 millimetres in length, brownish-yellow colour; the elytra carry black projecting points which impart to them a shagreen appearance. The larva of the saperda is one of the most dangerous to young poplar plantations. The eggs are arranged in fissures of the bark, the larvæ perforate these and bore ascending holes in the wood. The metamorphosis lasts two years and nymphosis occurs near the exit hole. The trunks of certain poplars, less than twenty years old, are sometimes riddled with holes to such a pitch, that a slight gale suffices to cause them to fall.

SAPERDA POPULNEA (saperda of the poplar).—This saperda is only 10-12 millimetres in length; it is blackish-brown; the elytra are spotted with small yellow dots. The female lays its eggs in the branches of the poplar. The larva penetrates into the branch, and there bores a long hole. Its presence is indicated by a circular swelling of the bark. The branches attacked show swellings, termed galls. The larval life last two years.

SCOLYTES.—The scolytes are small-sized coleoptera, which the number and nature of their depredations render very injurious to forest and fruit trees. They bore holes of various shapes, for the most part between the bark and the wood, in which the female lays its eggs. The larvæ bore secondary holes, which sometimes penetrate directly and deeply into the wood. They preferably attack sickly trees, because the circulation of the sap is not so intense as to hinder their mining work. Their presence is indicated by the leaves yellowing without a fixed reason. The scolytes greatly resemble the hylesines; they present the peculiar character of having an ovoid head, covered with a tuft of hair, the antennæ, terminated by a highly developed swelling, and the abdomen truncated at its upper and posterior part.

SCOLYTUS OF THE PLUM. *Scolytus Pruni.*—It ravages plums and apple-trees. The larvæ bore their holes in the liber and there pass the winter in the nymph state. The nsects hatch in April and lay their eggs in May. The foliage of the invaded trees is scanty, their growth is sickly, and they do not yield fruits.

SCOLYTUS (RUGOSE). *Eccoptogaster regusosus.*—It preferably attacks small branches and limbs. The perforated parts of the tree turn yellow and die. Plum-trees are especially chosen by it.

SEPTORIA.—These are parasitic fungi of the leaves. They produce withered and discoloured spots on which there are formed, below the epidermis, picnydes, which have pierced through the mouth of a hole through which the spores escape. There are more than 500 species of *Septoria*, but the small spots which they produce on the leaves are, in general, without serious consequence.

SEPTORIA TRITICI, SEPTORIA GRAMINUM.—In the spring the leaves of autumn wheat are covered with spots; this fungus exhausts the leaves which wither and die prematurely.

SESIÆ.—Butterflies, which have a portion of the wings transparent, which causes them to resemble wasps and flies. Their caterpillars are miners and live in the trunks of trees where they produce the same depredations as the caterpillars of the Cossus and the larvæ of the Saperdæ.

SESIA APIFORMIS. *Trochilium apiformi.*—Butterfly resembling a wasp. It shows itself in June. The female lays its eggs at the base of white-wood trees (poplar, birch, willow, aspen). The caterpillars bore holes, which may traverse the tree from one part to another, and even reach the roots. The metamorphosis lasts two years.

SESIA MYOPIFORMIS. — The caterpillar lives in the interior of the trunk of the pear-tree and the apple-tree.

SILPHS.—Silphs preferably attack decomposing animal matter; but certain species form an exception and attack cultivated plants.

SILPHA OPACA (beet carrion beetle). SILPHA ATRATA (black sylph).—Coleopteræ, 1 centimetre long, entirely blackish-brown, the corselet is highly developed, and in the form of a shield. The larva attains $1\frac{1}{2}$ centimetres in length; it is black and resembles a large wood louse. These insects cause serious damage to beet fields. Their invasion of France dates from 1846. They have spread in such numbers as to lay waste the departments in the North of France. The larva of great voracity attacks beet leaves; it hides all day in the soil, and only issues forth at night to commit its depredations. It appears in May to nymphose in the soil in June.

SPHÆRIACEÆ.—The *sphæriaceæ* comprise a great number of saprophytic fungi, or parasites; they have small, black, and not very visible peritheca. These fungi often cause serious damage to cultivated plants.

SPHÆRELLA FRAGARIÆ (spots of the leaves of the strawberry).—The leaves attacked by this fungus are covered with purple-brown rounded spots, separate or contiguous, which appear on their upper face. They increase rapidly in size, wither in the middle, and are finally pierced right through. On these spots all the conidia are formed, which readily germinate on the strawberry leaves. When it bleeds with intensity it may stop the growth of the fruit and kill the plant.

SPHÆRELLA TULASNEI (black of cereals).—In moist weather cereals become covered with black spots. The fungus cladosporium, which produces this disease, shows itself very commonly on the dead parts of very different plants, and it lives generally as a saprophyte. The black of cereals may cause rather great damage, the leaves wither and turn grey, the stalks die without producing ears.

TENTHREDO (saw-fly) OF THE TURNIP. *Athalia Spinarum.*—The larva of this saw-fly attacks the turnip, it gnaws the parenchyma of the leaves. Two annual generations—June and September.

TETRANYCHUS TELARIUS (red spider).—A red, polyphagous acarus, it attacks the most diverse plants, chiefly trees, haricots, peas, clover, pumpkins, beets, hemp, hops, roses, limes, chestnuts, willows, and fruit trees. It produces the same symptoms on all these plants. The leaves, prematurely discoloured, become copper yellow or red, and eventually wither, to fall before the end of summer. The under surfaces of these leaves are covered with a very fine light tissue and white pellicles, in the midst of which the red acarus moves. If the trees be examined, the limes for example, deprived in this way of their leaves, the branches are found covered with a silky tissue containing thousands of acari. These acari are accustomed to quit the leaves in autumn, and to hide themselves round the buds to pass the winter; they even often attack these, and deform them up to the moment of their exodus in the month of May, towards the young leaves produced by the healthy buds. The constant irritation, produced on the leaf by the rostrum of these acari, excite the cells, which multiply abnormally and produce characteristic deformations, brown rust, erinoses, galls, etc., forming propitious shelters for these acari. They produce on kitchen garden plants and on fruit trees the disease known by gardeners as *Grise* and the *Red disease* of the vine.

THRIPS OF CEREALS. *Thrips Cerealium.*—This hemiptera of 2 millimetres is a dangerous parasite. The larvæ attack the ears of wheat, rye, and barley, where they suck the newly formed grains, and stop their development. The adults, crawling always on the most tender leaves of the plant, suck them and wither them. Its damages, it appears, are not confined to cereals; the thrips likewise attacks strawberries, peas, etc.

TINEA.—Small moths distinguished by long antennæ, narrow and pointed at their extremities, and by large fringes which line the periphery of their wings, especially the lower wings. The caterpillars, known under the vulgar name of mites, commit serious havoc.

TINEA OF FLOUR. *Asopia farinalis.*—Butterfly of 24-25 millimetres from tip to tip. Upper wings yellow in the middle, and brown at the summit and the base. The lower wings grey, with two bright lines. The caterpillars live in flour and bran.

TINEA OF GRAIN. *Tinea granella.*—The tinea of grain is a butterfly a little larger than the preceding. It causes damage during the first fortnight of August. The female seeks the wheat granaries, there to lay its eggs on the grain. The caterpillars, known as the white-worm of wheat, hatch in eight to ten days and attack several grains at a time, uniting them by a tissue, in the shelter of which they gnaw them on the outside.

TINGIS PIRI. *Tiger of the Pear-tree.*—This brown flat hemiptera, 3 millimetres in length, appears in June. Larvæ, grubs, and adults live as one family on the lower surface of the leaf or the young shoots, and riddle them with their pricks. The young shoots wither and the leaves brown. The tiger preferably attacks pear-trees grown on an espalier, and its depredations are most terrible in August and September.

TIPULA OLERACEA (meadow tipula). TIPULA PRATENSIS (garden tipula).—The tipulæ resemble large gnats with long legs; the body is grey, highly elongated. They are 2 centimetres long. They may be seen flying above meadows in summer. These large mosquitos lay their eggs in June in the soil. The larvæ, which hatch in eight days, live underground, where they attack the radicles of kitchen garden plants and ornamental plants. They are particularly injurious to meadows, to grass plots, and to cereals, of which they not only attack the roots, but also the leaves in the spring (Ritzema Bos).

TYLENCHUS TRITICI ("ear cockles," "purples," "false ergot," galls of wheat, eel-worms of wheat).—The eel-worm of wheat is a very small filiform worm with a smooth tegument which twists its body like an eel, hence the name given to it; length 3 millimetres. The ears attacked in place of ordinary grain have small, rounded, blackish grains like smutty grains. If a section be made of one of these grains there will be seen under the hard, thick shell a white farinaceous mass consisting of thousands of small anguillulides in a dormant state of life and perfectly immobile. A little moisture suffices to awake them, which invariably comes when the smutty grain is sown. These eel-worms may preserve their vitality for two and a half years in the grain. Once they issue from their home they instal themselves on the young plants, ascending as the stem rises; reaching the young ears they penetrate the still milky grains where the females deposit their progeny. These small microscopic worms cause the disease known as earcockles. In the spring when the young stems of spring wheat are infested with eels the leaves are goffered and folded, the plant, instead of growing in height, tillers.

UROCYSTES CEPULÆ (smut of the onion).—This smut causes considerable havoc in America. It has been observed in France by Cornu. It attacks the bulbs of the onion when very young and kills them. Its presence is indicated by obscure spots on the leaves of the young onion, whilst in germination the leaves split longitudinally and show a withered tissue covered with black dust. The smutty spots afterwards extend on the bulb and invade it at its base.

USTILAGO AND TILLETIA.—(1) *Ustilago* smut which destroys all the parts of the flowers, and only leaves of the ears of barley and the clusters of oats the axis and the hulls. (2) The stinking smut or bunt of wheat *Tilletia*, which only attacks the grain which it replaces by its organs of reproduction.

USTILAGO.—The mycelium of the *Ustilagineæ* live in the interior of the plant; it gives rise to numerous fertile branches, inside which the spores are formed, which detached form a black powder. These are the dormant spores. *Ustilago Maydis* (maize smut) may directly invade the young tissues of the adult plant. None of the other *Ustilagineæ* can enter the nurse plant except at the birth of the latter. The mycelium which develops forthwith in the tissues of the seedling on the level of the ground, extends gradually into the whole plant without perceptibly affecting the growth of the latter. It afterwards traverses the whole nurse plant, and whilst life is gradually extinguished in the lower parts of the plant it concentrates itself towards the top and arrives at maturity in the ears at the end of the period of growth of the plant. The black spores which are formed, and which spread themselves on the adult plants, do not cause the disease. These spores generally pass the winter and may remain, according to circumstances, several years in the latent state. The following spring they germinate (if the conditions are favourable); they can germinate in a few hours; there is first formed a promycelium which produces sporidia. The latter if detached from the promycelium are capable of reproducing the disease if they encounter a young nurse plant. They then penetrate it at the base of the stem or the beginning of the root. Amongst the *Ustilago* these same winter spores, if they are brought into a nutritive medium in a soil manured with farmyard dung, and especially with purin, may multiply like leaven without producing promycelium or sporides, and live as saprophytes until they meet with the seedling cereal. The spores of *Tilletia* are enclosed at harvest time in the interior of the rusted grain and are almost all carried to the granary where they are spread over the corn during threshing. It is not so with the spores of *Ustilago*. The spores of this fungus being open to the air at the time of the flowering of the cereals, the greater part falls on the soil or is carried away by the wind. At harvest time the seeds only bear few spores on their surface. See Bunt, p. 388.

USTILAGO MAYDIS (smut of maize).—This smut attacks the fructified maize, not only in the floral bracts where it forms large, unshapely smutty tumours on the panicles of the male flowers, but also on the stems themselves where the amassed spores form bulky excrescences.

USTILAGO PANICI MILIACEI (smut of millet).—It invades all the parts of the flower of millet and damages them. The spores are formed in the inflorescences when they are yet enveloped in the sheath of the top leaf.

VESPERUS XATARTI.—Greyish longicorn coleoptera, 2 centimetres in length. The female of this coleoptera lays 200-500 eggs in the beginning of winter under the bark of vine stocks. The small larvæ issue in the end of April, bury themselves in the soil, and gnaw the roots of the vine. They take three years to reach maturity, and attain the size of the white-worm. This insect is spread chiefly over the north of Spain, and in France, in the departments of the Pyrénées-Orientales and Aude. Its ravages have been reported, especially in the communes of Banyule, Port Vendres, and Collioure, where it annually destroys from 50-60 hectares (125-150 acres) of vines.

WOOLLY APHIS. *Schizoneura lanigera.*—This aphis has great analogy with the phylloxera; it lives like the latter, as well on the roots as on the aerial part of the plant, but it prefers the branches to the roots. It especially attacks the apple-tree. From the winter egg issue, especially in the months of November and December, parthenogenetic individuals which yield numerous gemmations of similar individuals. From 18 May to 12 September Kessler observed ten generations; in summer there was a swarm every fortnight. The aphis hatched in August have wings and produce eggs from which issue sexual individuals deprived of wings and of suckers. After sexual intercourse the female lays a single egg. The woolly aphis, distinguished by the thick down covering them, are grouped in colonies on the branches and on the edge of the wounds and sink their dart, as shown by Prillieux, as far as the cambium. The activity of this part of the wood being soon increased, it gives rise to abnormal tissue, to nodosities which split deeply and end in forming cancers, which cause the rot of the branch. Kessler and Goethe have observed this disease on apple-tree and pear-tree roots, on which it forms the same nodosities. The diseased condition of the trees is known by their perishing, and their leaves which rapidly turn yellow and fall during summer. The woolly aphis descend on the roots to a depth of 65 centimetres (26 inches).

ZABRUS GIBBUS (zabrus of cereals). French: *Carabe bossu.*—Black coleoptera, 1½ centimetres long, with an accentuated prominence of the throat. It attacks corn crops in June in the night and devours the milky juice. The larvæ are as injurious as the perfect insects; they are yellow, with cross plates; they remain hidden in the day in the burrows dug in the soil, and issue at night to devour the wheat in the blade, they commit their depredations in autumn as well as in spring for they take two to three years to metamorphose.

ZEUZERA ÆSCULI (wood leopard moth).—The caterpillar of this bombyx has analogous habits to those of the *Cossus ligniperda* (*q.v.*); it attacks chestnut-trees, elms, limes, birches, oaks, apple-trees, pear-trees, and others; its life as a caterpillar also lasts three years.

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